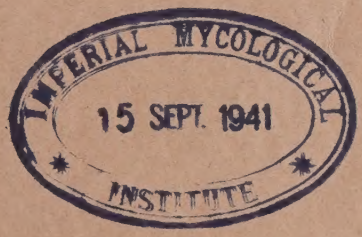
THE

Journal of the

AUSTRALIAN INSTITUTE OF AGRICULTURAL SCIENCE

PUBLISHED QUARTERLY



SUBSCRIPTION PRICE:

10/6 per Volume of Four Numbers, post free; Single Copies, 3/-.

Issued Free to Members of the Australian Institute of Agricultural Science.

Registered at the G.P.O., Sydney, for transmission by post as a periodical.

VOL. 7, No. 2. JUNE, 1941.

THE NATIONAL BANK

OF AUSTRALASIA LIMITED

(Incorporated in Victoria)

Head Office and Registered Office:

271-279 COLLINS STREET, MELBOURNE, C.I
AUSTRALIA

BOARD OF DIRECTORS:

SIR JAMES A. M. ELDER, K.B.E., *Chairman.*
THE HON. SIR FRANK G. CLARKE, K.B.E., M.L.C., *Vice-Chairman.*
T. C. ALSTON. GENERAL SIR HENRY G. CHAUVEL, G.C.M.G., K.C.B.
H. G. DARLING. H. D. GIDDY. D. YORK SYME.

Chief Manager: L. J. MCCONNAN.

Chief Inspector: S. M. WREFORD.

Auditors: JOHN BISHOP (F.C.A., AUST.); S. J. WARNOCK (F.C.A., AUST.).

Boards of Advice:

LONDON—THE RIGHT HON. LORD INVERFORTH, P.C., *Chairman.*
THE RIGHT HON. LORD HUTCHISON OF MONTROSE, P.C., K.C.M.G., C.B., D.S.O. SIR JAMES LEIGH-WOOD, K.B.E., C.B., C.M.G.

NEW SOUTH WALES—THE HON. T. A. J. PLAYFAIR, D.S.O., O.B.E., V.D., M.L.C., *Chairman.*
RODNEY R. DANGAR. HUNTER WHITE.

QUEENSLAND—SIR EDWARD H. MACARTNEY, *Chairman.*
BYRNE HART. DE BURGH B. B. PERSSE.

EXTRACTS FROM BALANCE SHEET, 31st March, 1941

LIABILITIES.

Capital Issued—		
200,000 £10 shares, fully paid	£2,000,000	
600,000 £8 shares, paid to £5 per share	3,000,000	
Capital Paid Up		**£5,000,000**
Reserve Fund (used in the business)		**3,300,000**
Deposits and Other Accounts		**49,750,914**
Notes and Bills in Circulation		**1,850,580**

ASSETS.

Coin, Australian Notes, Cash at Bankers, Cheques and Bills in Transitu	**7,914,430**
Investments and other Liquid Assets	**14,798,418**
Bank Premises, other Real Estate, etc.	**1,373,406**
Advances and other Assets	**36,108,818**

TOTAL ASSETS £60,195,072

Dividend for the year is at the rate of six per cent. per annum.

THE ORDINARY GENERAL MEETING OF SHAREHOLDERS will be held at the Head Office of the Bank on Wednesday, the 28th day of May, 1941, at 11.30 a.m.

The Publishers, Proprietors and Editor of this Journal take no responsibility for claims or statements made by Advertisers.

CONTENTS

Agricultural Efficiency and its Relationship to Production Costs, by A. W. S. Moodie 49

The Effective Period for Controlling Fruit Cropping, by F. T. Bowman 56

Modern Methods of Clearing and Developing Poor Land in South Australia, by T. H. Strong 61

Irradiation of Cheese Moulds and Bacteriophage by Ultra Violet Light, by W. S. Sutton 67

Internal Grain Infection in Maize, by E. T. Edwards 74

Technical Notes—

Response to Zinc on a South Australian Soil, by D. S. Riceman and A. J. Anderson 82

Some Common Insects of Lucerne in New South Wales, by C. R. Wallace 83

Occurrence of Ergot in Queensland, with Special Reference to *Claviceps pusilla* Cesati, by R. F. Langdon 85

The Australian Institute of Agricultural Science—

Meetings of Council 87

Meetings of Branches 87

Current Notes and News 88

Personal Notes 90

Standardised

HORTICULTURAL REMEDIES

We manufacture in Australia a comprehensive range of Horticultural Insecticides and Fungicides. These have all been tried and tested under local conditions and can be recommended with confidence.

We are also sole distributors of the complete range of Horticultural Pesticides manufactured by Messrs. Imperial Chemical Industries of Australia and New Zealand Ltd.

Pamphlets, prices and full particulars posted free on application to

WILLIAM COOPER & NEPHEWS (AUSTRALIA) PTY. LIMITED

Cooper House, 9 O'Connell Street, Sydney

SUPPORT BRITISH INDUSTRY

SCIENCE FREQUENTLY REQUIRES COMMERCE to make commercially practicable what it has demonstrated as possible. Particularly is this so in the field of ANIMAL NUTRITION.

THORPES LTD.

have the most complete plant in the Southern Hemisphere for the supply and preparation of concentrated feeds for Stock and Poultry.

The Company's ideal is PURE FEEDS, and Veterinary Officers and Scientific Investigators can rely on any feed bearing the Company's brand being exactly what it is represented to be. The Company is always ready to co-operate with scientific workers in the field of Animal Nutrition.

THORPES LTD. **Stock Feed Manufacturers,**
313-317 SUSSEX STREET, SYDNEY
Frank C. Sargeant, Managing Director.

Costs the Least
Contains the Most
Mixes the Best
Resists Leaching

Ammonium Sulphate

That's why it's chosen as the STANDARD for comparison in most Agricultural experimental work all over the world.

Hence, too,
THE GROWER'S PREFERENCE

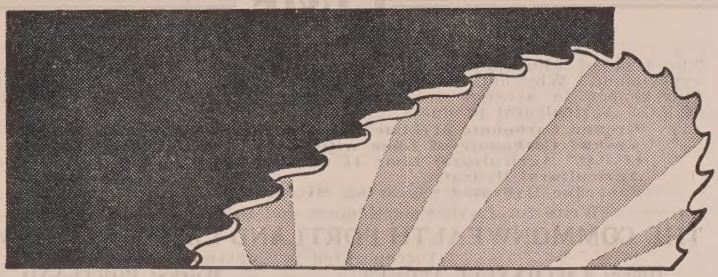
YOU NEED PESTEND TO KEEP YOUR GARDEN FREE OF PLANT PESTS!

PESTEND SUPERFINE (TOBACCO DUST)

It lasts longer, adheres better, acts more quickly and costs less than ordinary spraying powders. Expert gardeners and growers recommend Pestend Superfine for dusting, spraying or for dressing the soil. Pestend Superfine is sterilized, therefore non-poisonous and non-injurious to plants.

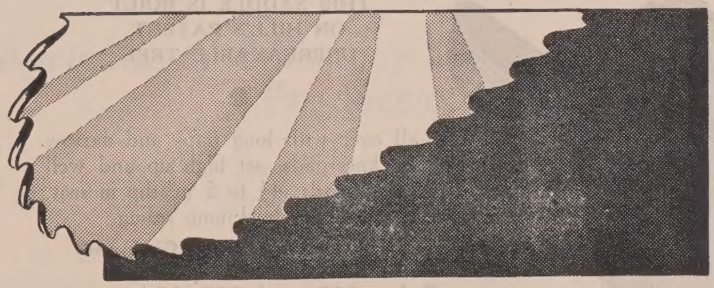
OBTAINABLE IN 28 LB. AND 56 LB. BAGS AT ALL PRODUCE STORES AND W. D. & H. O. WILLS (AUST.) LTD., IN ALL CAPITAL CITIES

180-7.9



"An Eagle on a Globe" Brand

CIRCULAR SAWS
CHAFF-CUTTER KNIVES



Circular Saws from 6" to 78"
... Band Saws ... Frame Saws
... Chaff - Cutter Knives ...
Hacksaw Blades ... Files ...
High Speed and Tool Steels
for all purposes.

● *We are experts on all types of Saw Repairs. Re-sharpening, Re-grinding, Smithing and Gulleting.* ● *All well-known makes of Chaff-Cutter Knives supplied immediately.*

THE EAGLE & GLOBE STEEL CO. LTD.

SYDNEY, MELBOURNE, ADELAIDE,
PERTH, BRISBANE, HOBART.

(Incorporated in England)

379 KENT STREET, SYDNEY. Telephone: MA 6421. Telegraph: "Yartis"

LIME

LIME for the SOIL

The type of Lime most suitable for your soil can best be determined by experiment. Why not consider ordering composite trucks or **ask** your local Storekeeper to arrange to supply you with any of the undermentioned "C.P.C." Agricultural products:

Ground Carbonate of Lime (Ground Limestone)
Ground Carbonate of Lime with Magnesia (Dolomite)
"C.P.C." Agricultural Lime (¼ carb., ¾ hyd.)
Agricultural Hydrate.
Superfine Hydrated (Spraying Mixtures)

Write for further particulars and prices—also pamphlets.

THE COMMONWEALTH PORTLAND CEMENT CO. LIMITED
(Incorporated in England)
Office: 4 O'CONNELL STREET, SYDNEY **Works: PORTLAND, N.S.W.**

CHAMPION POLEY

THIS SADDLE IS BUILT ON HILL'S PATENT UNBREAKABLE TREE

●

Best Kip all over with long flaps and narrow waist, 4½ in. knee-pads, set high up and well back, 3 in. thigh-pads, 4½ to 5 in. dip in seat. It is a great saddle for buckjump riding.

Mounted with Leathers, Irons, Girth and Surcingle.

Price £12 and £13/13/-

Freight Paid.

J. P. TALTY

Manufacturer of SADDLERY, HARNESS, CANVAS GOODS

6 CUNNINGHAM STREET, SYDNEY

Off Goulburn Street, between Pitt and George Streets

For Quality in Produce, you cannot do better than

M. MALONEY

● **PRODUCE MERCHANTS**

185 Sussex Street, Sydney

The Journal of

THE AUSTRALIAN INSTITUTE OF AGRICULTURAL SCIENCE

Registered at the G.P.O., Sydney, for transmission by post as a periodical.

Editor :
H. J. HYNES, D.Sc.Agr., M.Sc.
Address : Box 3819T, G.P.O., Sydney, N.S.W.

Business Manager :
N. S. NOBLE, D.Sc.Agr., M.Sc., D.I.C.
Address : Box 3819T, G.P.O., Sydney, N.S.W.

VOL. 7, No. 2 JUNE, 1941

Agricultural Efficiency and its Relationship to Production Costs*

By

A. W. S. MOODIE, H.D.A., H.D.D.,
Senior Agrostologist, Department of Agriculture, Sydney.

In selecting the subject, "Agricultural Efficiency and its Relationship to Production Costs", my principal object is to present certain suggestions regarding a few phases of our agriculture which appear to be of some importance at the present time. Particularly do I wish to draw attention to the need for the formation of a unit to study and investigate the economics of farm management with special regard to the influence of technology on production costs.

For reasons which need not be discussed, the agricultural industries of many countries are in a parlous condition. As far as Australia is concerned producers in some primary industries claim that price levels are so low that profitable production is impossible. In the dairying industry it is asserted that the returns earned by the farmer and his family are frequently less than the basic wage. From personal experience I know that in many instances this is quite true. On the other hand I know many dairyfarmers, formerly tenants and sharefarmers, who in a comparatively short time managed to save enough to purchase their own properties.

Disregarding price levels, we know that at least two major industries face competition from substitute materials, that wheatgrowing has proved to be unprofitable in some zones, our overseas market for wine has been lost at least temporarily, and that we face intense competition on overseas markets from highly organised and efficient competitors.

In view of the many difficulties besetting primary producers it seems obvious that every industry should be studied carefully so that in the event of adjustments becoming necessary, they may be planned and executed smoothly and efficiently. A prerequisite to such planning must be factual information regarding the economics of the industries concerned, and not claims and counter claims regarding price levels.

* Presidential address to the N.S.W. Branch of the Institute, 14th February, 1941.

In regard to the adjustment of economic problems in agriculture, it may be found that Australia possesses advantages enjoyed by few of her competitors. Admittedly the necessity of disposing of large exportable surpluses, long haulage to overseas markets, and high prices for certain manufactured goods impose complications and difficulties. On the other hand, we enjoy immunity from the necessity for housing and hand-feeding stock every year, practices involving high labour costs and interest on capital invested in buildings. Grass feeding is recognised as the cheapest means of feeding stock and in this regard our stock raisers possess an advantage enjoyed by few other countries. With a climate extremely favourable to animal health, it should be possible to reduce losses to a minimum by close attention to nutrition. Should it be necessary to reduce the amount of wool produced, many areas at present devoted to this product almost solely could be utilised for the production of fat lambs and beef. The dairying industry is finding new outlets for milk products and, finally, we have markets unexploited near at hand.

There would seem to be sound reasons for believing that at least as far as the stock raising industries are concerned the future may be made reasonably secure if essential adjustments are made as required. What does seem to be of far greater national significance is the future prosperity of these industries when considered in relation to diminishing soil fertility and the apparent apathy in some quarters regarding technical efficiency. This attitude towards improved practices is sometimes due not to disinterestedness but to lack of reliable information regarding the reactions of the farm business as a whole following their adoption.

Gradually diminishing soil fertility is reflected almost imperceptibly in contracting yields and carrying capacity, increasing mortality from diseases, and higher production costs. It may be claimed that there is little if any evidence to support this view, that our production is actually increasing. This can be explained by factors which I need not discuss in detail but which in general are concerned with rural development in any new country.

Diminishing Soil Fertility.

No one closely associated with the land will question the view that soil fertility has diminished, nor that it is reflected in reduced production on many holdings. We have areas where it was once possible to graze one beast to the acre and where three acres to the beast are necessary today; others where dairying was once a prosperous industry but where it is now virtually impossible. In some inland areas decreased soil fertility is reflected in reduced carrying capacity and a higher disease incidence.

The restoration of soil fertility is one of the major problems involving farm economics, and there seems little doubt that an investigation of this and associated problems would almost inevitably result in radically changed conceptions of the practical applications of improved methods. These investigations should be conducted by economists possessing a sound knowledge of the industries concerned, in collaboration with technicians. The primary task would be a farm management survey. To illustrate the type of investigation I believe to be necessary and which would be of incalculable benefit to many farmers, I propose to deal in some detail with the dairying industry. I have selected this industry because of personal close contact with it for over twenty years and because of the numerous claims made for higher price levels for dairy products.

One of the factors frequently responsible for soil exploitation, general inefficiency and high production costs is excessive farm areas. I say this, at the same time recognising the principle that large units can usually be worked more economically than small units. This factor is particularly potent when taken in conjunction with other contributing factors such as satisfactory price levels, cheaply acquired land, and an equable climate. Land utilisation in New South Wales is characterised

by low rates of carrying capacity. In districts of assured rainfall one sheep per acre or one beast to 3–5 acres is usual. With large holdings and satisfactory price levels it has been possible to carry on without undue worry or overmuch thought to the future. On crop farms it has not been necessary to conserve and build fertility because when reduced yields became evident the land could be permitted to revert to grass.

With the volume of farm business contracting in numerous instances it is natural that the reaction should be claims for higher prices and larger holdings. To convince farmers that decreasing or insufficient volume of business is the basic cause of much of their trouble is likely to prove difficult. We have been blessed with so much land that the remedy for contracting production or to provide for increasing numbers of stock has been to acquire more land. This tradition is becoming difficult to follow today on account of increasing land values and the danger of over-capitalisation ; but it will be realised that the task of convincing the farmer that his hope of salvation rests in disposing of some of his land and adopting improved methods would be one of some magnitude.

This problem of unit areas and their relationship to production costs is one requiring immediate scientific investigation. Many farmers realise that their holdings are deteriorating, but when remedial measures are suggested the area involved is often quoted as an insurmountable barrier to their adoption, at least on a farm scale.

It seems possible that this problem of restoring fertility will resolve itself into one of reducing the area of holdings in some instances, at the same time increasing the volume of production by improved technical efficiency. Larger unit areas and higher capitalisation unless followed by a corresponding increase in the volume of business would only aggravate the position.

Overcapitalisation of Farms.

Considered in relation to the volume of business, overcapitalisation in land must be responsible for the sorry plight of numerous farmers today. Land valued at £40 an acre, carrying a milking cow to three acres and producing about 60 pounds of butter an acre must be difficult to farm successfully unless the land has been inherited, and the position is probably much the same when £7 or £8 an acre is invested in land producing seven or eight pounds of wool per acre. I feel convinced that some holdings are so highly capitalised in relation to the volume of business, often the result of technical inefficiency, that profitable working is virtually impossible. The earnings of some dairy farmers are scandalously low, but higher price levels alone would not rectify the position.

The contention that reduced unit areas and improved technology would often be instrumental in increasing the volume and reducing costs of production, at the same time maintaining or actually increasing soil fertility, can be supported by evidence which at least points in this direction. Some farmers finding it impossible to apply improved methods of grassland management to their entire holdings, have concentrated on sections representing perhaps one-third or one-half of the total area and have found that the total volume of production could be maintained, in some cases actually increased considerably, on the treated area alone. In one instance a holding of 143 acres carrying 35 cows was reduced by sale to 90 acres and in 1939, following three years of pasture improvement, the production was double that obtained in 1936. Another property in a locality nearby increased production from 6,000 pounds to 12,000 pounds of butter as a result of pasture improvement and better feeding generally.

The extent to which this principle could be applied to the dairying and other industries surely warrants close investigation. In this connection it is worthy of

note that a few farmers are beginning to think along similar lines. Rather than burden themselves with additional land and capitalisation, they are concentrating on small areas and improving efficiency. In my own experience I have known farmers to dispose of portions of their holdings with the express purpose of investing the money in the area retained.

In some quarters in the dairying industry it is claimed that current price levels are solely responsible for failure to conserve and rebuild soil fertility, and that only by neglecting this and other measures which we consider essential to efficiency can the industry continue to exist. One of the functions of a Farm Management Survey Unit would be to investigate and endeavour to arrive at the true position regarding these matters.

Technical Efficiency.

So far my remarks have been confined to farm unit areas and their possible influence on production costs and soil fertility. Large unit areas also contribute to inefficiency in respect of technical applications but as similar inefficiency is encountered on small holdings it is my intention to deal with some matters generally as technical factors influencing production costs.

Failure to conserve adequate reserves of fodder during periods of abundant growth results in the necessity to maintain stock during adverse periods on fodders purchased at drought prices or, alternatively, to allow production to decline. Every farmer knows that under our climatic conditions pasture production cannot be maintained at an even plane and that periods of shortage are inevitable. Let figures illustrate the insurance measures adopted. The Statistical Register for 1938-39 shows that silage was conserved on 911 farms in coastal districts, of which 672 were located on the south coast and in the metropolitan area, and the total amount conserved was 75,682 tons. The quantity of hay produced was 58,657 tons, mainly consisting of lucerne produced on the lower north coast, a considerable proportion of which would no doubt be sold on the city market. The total number of dairy cows in the zone concerned was 961,802, so that the amount of silage available was approximately $1\frac{1}{2}$ cwts. per cow, equivalent to a ration for four or five days.

To view silage purely as an insurance against drought is to ignore the fact that balanced pastures cannot be maintained at all seasons of the year, even when conditions are favourable, and that supplementary feeding is necessary for high producing cows if they are to be well fed. From the figures quoted it may be assumed that the practice of conserving fodder is neglected to such an extent that the total production is not influenced by the small amount conserved. Failure to provide an adequate and properly balanced diet must surely be another factor contributing to low volume of business and high costs of production.

In sheep and beef cattle raising, failure to conserve fodder is responsible for avoidable direct losses as well as slow maturity and reduced market values. Under nutrition and an unbalanced plane of nutrition are responsible for disorganisation in marketing and low volume of production, and lead ultimately to higher costs.

A perusal of production figures from various farms indicates the influence of fodder conservation, pasture improvement and improved methods generally on the volume of business. It is common to find that two-thirds of the total production of milk or cream occurs during the period April to October. On the other hand farmers who make adequate provision for supplementary feeding are able to maintain production on a high plane throughout the year. The claim that high winter production cannot be secured on an economic basis is often made, but is one that cannot be substantiated. Finally it can be proved beyond doubt that inadequate

feeding is responsible for the low volume of business on many farms. To what extent this factor is responsible for high costs of production is surely a matter worthy of investigation.

Another matter in which inefficiency is reflected in low production is the quality of the livestock found on many dairy farms. There are far too many animals incapable of reasonable production, yet costing as much to maintain as high producers. Labour utilisation cannot possibly be efficient in the case of herds of poor quality animals. The common practice of running heifers and dry stock on pastures deficient in minerals is a factor to be considered in this connection.

Many farmers who refuse to support herd testing maintain that the salvation of the industry depends on higher price levels. In a recent dairy farm competition five of the herds were not being tested at the time of the competition ; two of these had never been tested and proved to be the ones giving the lowest returns. It was found also that annual butter production per acre varied from 18 pounds to 142 pounds and that the higher the return per acre the lower was the feed cost per pound of butter produced.

The accepted means of measuring farm efficiency is in terms of production per acre, or the number of productive stock carried per acre and the production per head of stock. In a grassland competition just concluded, the winning farm produced 18,344 pounds of commercial butter for the twelve months prior to judging, which indicates a good volume of business. The return of butter averaged 100 pounds per acre. In a similar competition in 1939, there were 45 entries, of which only two produced 100 pounds of butter per acre. Investigations in New Zealand have shown that where the butter fat production is 60 pounds or less an acre the costs of production are very high. In the groups studied, working costs, interest, labour and net cost of production were each expressed as 100. In groups where production exceeded 180 pounds butter fat, working costs were 76, interest 60, labour 71, and net cost 79.

Applying the same system to yields per cow it was ascertained that when the average production per cow was under 180 pounds of butter fat the costs were 100 and over, whereas when the average exceeded 300 pounds the working costs, interest, labour and net costs were 64, 64, 62 and 68 respectively.

I have referred previously to the basic need for increasing the volume of business on the farm by improved methods, and in this way reducing production costs. A survey in New Zealand revealed the following striking information on this point. Where total production was less than 5,000 pounds butter fat, the figure 100 again being used to express the various items, costs were high to very high. Increases in the volume of production were followed by progressive reductions in costs culminating in the group 17,000 pounds butter fat and over. In this group the figures were working costs 63, interest 93, labour 42, net cost 60. It is worthy of note that £42 spent on labour in the high production group was equivalent to £100 in the low production group. Labour utilisation is one of the most important factors in profitable farming. If the stock are poor and the feeding inadequate, labour output must be poor. In view of our " tested cow " average of 160 pounds, labour utilisation must leave a lot to be desired on many farms.

Land Tenure.

From the figures available it may be assumed that at least 36 per cent. of the dairy farms in coastal districts are worked by tenants and sharefarmers whose operations are governed by loose, often verbal, agreements. Tenants claim that landlords are interested only in immediate returns and will not assist in the task of maintaining soil fertility ; nor will they compensate the tenant for the use of lime,

fertilisers, fodders on hand at the termination of tenancy, sown pastures, and numerous items for which the English tenant receives compensation. In most instances the tenant works on an annual lease, if any, and there is no incentive to induce him to plan operations or to practise efficient methods.

This system is responsible for the volume of business being scandalously low on many farms and the tenant or sharefarmers' income a mere pittance. Many city dwellers would prefer the dole to the long hours and the peasant rewards earned by some sharefarmers. It is no exaggeration to say that we have a peasant class in N.S.W.

It is not my purpose to discuss this subject at length. The results may be summarised as contributing to soil exploitation and general inefficiency, and the only remedy the realisation by landlords that land is the heritage of each generation which is responsible for handing it on to future generations with fertility unimpaired, and that the right to own and hold land should be conditional on its proper use in the interests of the whole community.

The landlord tenant system as it operates today is against the best interests of the industry, the individual, and the nation. In 1927 the area of land worked on shares was 303,273 acres; in 1939, 810,519 acres.

In presenting these facts regarding the dairying industry I cannot refrain from comment on an aspect that has always intrigued me. On one hand, it is claimed that price levels are so low that profitable production is impossible. On the other hand, numerous farmers in many districts are and have been for years employing every possible means to improve their efficiency and volume of business. Individuals have more than doubled their output. Surely this is an illogical proceeding if the price level claim is true; yet to the best of my knowledge such men are prospering and have not been overwhelmed by the dreadful fate usually predicted for them.

Other Industries.

The dairying industry has been used to illustrate how improved technical efficiency could probably be reflected in reduced costs of production. The same system of analysis could no doubt be applied to all primary industries and similar deductions made. In many areas acre wool and meat outputs are inexcusably low, and improvements could be effected by the adoption of better methods. At all events, by following scientific study and analysis it should be possible to afford a greater measure of assistance to farmers willing to cooperate, at the same time building up reliable statistical information regarding the true positions of the industries concerned, which would be invaluable for planning adjustments when and if necessary.

The Farm Management Survey Unit.

My advocacy of the formation of a farm management survey unit is not made with the primary object of probing costs and price levels in the various industries, so much as to constitute an organisation which could afford greater assistance to the farmer than he is given today. Technical advice is readily available but there is no organisation to analyse his business in detail and provide the economic guidance necessary. Many of the usual technical recommendations involve expenditure and the farmer should be given detailed information as to how the outlay involved will influence his costs and returns.

The activities of a farm management unit would provide information essential for financing individuals on sound lines. From information I have obtained from farmers it seems evident that financial help sometimes adds to their difficulties.

Money advanced for the construction of silos, for example, is not invested wisely and makes a very limited contribution to working efficiency if the livestock lack the inherent qualities to respond to improved feeding. Similarly money advanced for subdivisional fencing, sown pastures, or the purchase of fertilisers is only adding to the farmers' burden and to his production costs, unless the areas treated are sufficient to increase the volume of business appreciably, and above all rapidly. The farm management survey would be able to study the farm business in all its aspects and make financial recommendations in accordance with its findings.

Another problem involving farm economics and finance concerns the extensive areas in coast and tableland districts still in the pioneering stages. Many farmers find it impossible to improve technical efficiency because their grasslands are covered by logs and stumps. Should they practise herd improvement, labour utilisation is still poor because of inadequate feeding. A farm management unit would study the situation in such areas and recommend the provision of finance where desirable. It would be necessary to determine the area necessary to be treated to place the farm on a sound economic basis and to predetermine the extent to which the farm business could be expanded as a result of improved methods. All factors would be considered in their proper perspective and financial arrangements would be on a scale sufficient to promote rapid expansion.

Such evidence as I have been able to secure seems to indicate that some financial institutions make advances to permit farmers to develop along one or two lines known to be sound, but pay little attention to the business as a whole as long as the security is good. Knowing something of the extent to which finance will have to be provided to develop certain country, and to restore fertility and productivity to other areas, I have no hesitation in saying that every case should be studied in relation to present efficiency, possibilities of improved efficiency, and the probable results on the farm business as a whole. With increased knowledge concerning the economics of farming it should be possible to evolve a more liberal outlook regarding farm finance.

A farm management survey unit should be attached to the Department of Agriculture. In this way it could operate in close collaboration with field and technical officers, would be in close touch with all technical developments as they occurred, and would be of inestimable service to farmers.

A simple but valuable service would be the provision of record sheets on which details of the farm business would be recorded for the purpose of facilitating analysis of operations and costs. Some farmers already maintain such records and are able to indicate the cost of any farm operation.

Another function would be the study of comparative methods and costs as between different farms by survey methods. In this way the most efficient practices in any district would be disclosed, in addition to indicating the status and efficiency of the industry concerned.

At the present time our knowledge concerning the economics of various primary industries is confined to the information disclosed in reports by the Tariff Board, various Royal Commissions and so forth. Such reports are of very limited value because the research on which conclusions are reached is not continuous and because much of the evidence is presented by interested parties. The consumer is becoming increasingly sceptical of the validity of the information gathered by such inquiries, feeling that in many cases they have been constituted to justify a predetermined course of action. A farm survey unit would be above such suspicion, and should it determine that higher price levels were necessary there would be little objection from the consumer who is definitely sympathetic to the man on the land, particularly when it is felt that he is being denied the full fruits of his endeavours.

(Received for publication, 14th February, 1941.)

The Effective Period for Controlling Fruit Cropping

By

F. T. Bowman, Ph.D., B.Sc.Agr.,

Fruit Research Officer, Department of Agriculture, Sydney.

The first four to five weeks after full bloom are of primary importance for the crop prospects of the current and the second season of deciduous trees. This period has been shown by three seasons' experiments on apples, following two seasons' detailed researches on prunes, to be the effective one in which to control alternate cropping by thinning.

The establishment of limits to the effective period provides an entirely new approach to the general problem of fruit cropping, as well as the particular problem of controlling alternate cropping. It indicates that new methods are needed that are radically different from those variations of ordinary cultural practices which have been used hitherto, in the attempt to regulate cropping.

Growth and Development in the First Thirty-five Days.

The first four or five weeks of the growing season after full bloom owe their importance to the fact that during this period are determined the fruit setting and the mean leaf and shoot growth of the current year ; also whether or not blossom buds will form in the current year for the second season's blossoming. These statements are based on the detail researches on alternate bearing prune trees[6] and the results of further time-of-thinning with alternate bearing Delicious and McIntosh apple varieties in New South Wales during the past three years.[4, 5]

Fruit Setting. For the Sugar Prune in California, the author[6] has shown that although the waves of fruit shedding started to appear at 31, 50 and 83 days after full bloom, they were actually initiated at 22, 31 and 48 days. Apple varieties in both early and late maturing districts in New South Wales have consistently shown during the past three seasons a first shedding commencing at 21 days, and a second at 35 days. Padfield,[11] also, has noted that the natural (final) shedding of Dunn's apples in New Zealand commenced to appear at 35 days. It is clear that these drops must have been initiated during the first month of growth, hence the actual time of initiation has not been traced by a technique similar to that devised and demonstrated for the prune, although it would be applicable.

The size of the fruit at shedding time has also been rather consistent ; the average size was about $\frac{3}{8}$ of an inch in diameter at the commencement of the first drop, and $1\frac{1}{8}$ to $1\frac{1}{4}$ inches in diameter at the commencement of the second drop.

Leaf and Shoot Growth. In bearing pome and stone fruit trees, except the peach and some plums, the vast majority of the shoots are spurs, and since they cease their length growth within one to two weeks after full bloom, and their leaf growth within a month of full bloom, the approximate mean shoot and leaf growth of the trees is determined very early in the season. Diametral growth is made mostly at a later period of the year. The term approximate mean is used as the true mean is not established till all shoots have ceased growth. However long shoots, the laterals and terminals, which may grow as late as three months, are so few in number that despite their individual great length and leaf area, they increase the mean very slightly. Even in trees in which the vigour is increased above average, and in which there are many

long spurs and short shoots, the approximate mean leaf growth is established by the end of the first month. This appears to be due to the fact that when increased growth is made it is made in its " grand period " of growth, which occurs early in the first month.

Critical Time for Blossom-Bud Formation. Time-of-fruit removal experiments with prunes demonstrated that a critical time for blossom-bud formation exists at between 30 and 35 days after full bloom. The critical time for apples in this State has been found to be similar, but for apples and pears[1, 2, 3, 8, 9] in Washington and Oregon, U.S.A., it has been found to be later, probably because of different climatic conditions in these higher latitudes.

If an excessive crop, which can be rather precisely defined, is carried beyond this stage, the primordia of blossom buds will generally fail to appear two months later ; consequently the trees will not carry blossom the next spring, and there will be no crop. In other words, a not excessive crop at 30 to 35 days is a necessary antecedent to blossom bud differentiation in mid-summer. Although it appears to be by far the major antecedent, it is not the only one. Subsequent growing conditions play a part, which, however, is not at all clear, because the evidence is conflicting. For instance, alternate bearing Delicious trees, given the needful antecedent conditions of fruit thinning yet failed to form blossom buds during the drought of 1938-39, so also in that year did whole plantations of previously regular bearing Jonathans. In the drought of 1939-40, on the contrary, some McIntosh apples not given the needful antecedent, and bearing their on-year crop, formed sufficient blossom buds to give one-quarter to one-third of a normal crop the next year.

The critical time, which has been repeatedly demonstrated by time-of-thinning experiments, is fundamental in nature, a similar period having been shown by a shading technique by Paddock and Charles.[10] These authors, who published twelve years ago, were in fact the first horticulturists to draw attention to the possibly unusual earliness in the growing season of a time when blossom buds might be initiated.

Excessive Blossoming and Setting.

Excessive numbers of blossoms and fruits developing during the first month after blossoming are the chief contemporary factors acting against the growth processes mentioned above. Because of extreme competition, most of them must necessarily shed off, after a development pointless in itself, and deleterious in its effects. They waste the reserves of plant foods upon which the tree depends for its first flush of growth ; they reduce the mean leaf and shoot growth ; in the prune they reduce, and in the apple greatly increase, the number of shoots, and prevent the predisposition at the 30 to 35-day period to later blossom bud formation.

Excessive Blossoming. An arbitrary figure has to be chosen from experience to indicate what is excessive blossoming. If 50 per cent. of the primary shoots form blossom buds, it should be sufficient to ensure a commercial crop in any year. A final commercial set of one fruit in every five of the total number of spurs of the tree would then be equivalent to eight per cent. setting of the blossom, indicating a great abundance of flowers to allow for the incidence of pests, diseases and climatic vicissitudes. Higher percentages may be regarded as excessive, and detrimental to vegetative growth and, in certain varieties, to blossom bud formation.

Excessive blossoming alone, and apart from when it is followed by excessive setting, has a marked effect upon the foliage. If only 50 per cent. of the primary spurs blossom, 50 per cent. are primary leaf spurs which expand earlier, attain a much greater leaf area, and thereby in all probability more

quickly contribute food materials to the plant than secondary leaf spurs which constitute almost all the leaf spurs of a tree which has blossomed excessively. A moderately blossoming tree, in addition to the primary leaf spurs, also produces its normal secondary leaf spurs from its primary blossoming spurs. Consequently the foliation of trees which have blossomed moderately is remarkably different from trees which have blossomed excessively in the first month of the growing season. It is especially different from those excessively blossoming trees in which some of the secondary spurs have been used up in blossom and produce no leaves and remain dormant. In such trees the foliation is extremely poor.

In the prune, excessive blossoming has been found to completely inhibit vegetative growth from as many as 24 per cent. of the leaf buds. In pome fruits, it greatly increases the number of growing points, since two and sometimes three short secondary spurs grow from each primary blossoming spur instead of the single shoot of the primary leaf spur. Consequently the average vigour is much reduced.

Trees of apples, pears and plums develop blossom buds excessively when they lose vigour from increasing age, insufficient care, or adverse seasons. The state of over-blossoming which may result from neglect of proper pruning and general cultural practices has been shown in prunes at Yenda, by the development of an average of nine flowers per leaf shoot instead of 4·5, where the trees were better tended. As a result of drought conditions particularly, apple trees may even produce a secondary or " false " blossom on their secondary shoots towards the close of the normal primary blossoming period. In these circumstances the weak spurs, particularly, may show 15 blossoms instead of five, and yet, being weak spurs, set no fruit.

Excessive Setting. Excessive setting refers to the conditions where too many fruits develop per spur during the first 35 days, and too many spurs bear such fruit. A distinction between excessive blossoming and excessive setting is necessary, since the one need not follow the other. In fact, when it does not, it gives a common condition of cropping in Packham's Triumph, Winter Nelis and other pears—the light set in the heavy blossoming year.

Excessive setting has to be realised and understood by reference to what is a final crop. It is shown by the fact that three fruits per spur may be carried up to final drop, whereas only 0·20 fruit per spur may mature as a final and satisfactory crop. The setting during the first month may thus be as high as fifteen times the final crop.

The effect of these excessive numbers of fruits is to depress the leaf and shoot growth. The leaf area of trees that have blossomed and set excessively is reduced to about 50 per cent. of a tree with a naturally moderate set or which has been blossom thinned or pre-drop thinned by 20 days after full bloom. If trees are pre-drop thinned almost at the close of the effective period, say 30 days, there is a visible but comparatively small increase in leaf area.

There is a considerable variation in seasonal excesses of setting. In 1938 excessive setting was very pronounced ; 90 per cent. of the spurs on on-year Delicious trees carried between three and six fruits per spur up to the November drop, commencing at 35 days. As a result these trees produced no blossoms the following year. Granny Smith, in regular bearing, and other varieties carried almost as much young fruit till the final drop, but produced a full crop the following year. Large areas of Jonathans, previously in regular bearing, set heavily till the final drop that year, and as a consequence failed to blossom the next. In the 1940 season, which was the return on-year of Delicious apples at Orange, the fruit thinned out very well, to such an extent that many trees carried only 0·3 to 0·5 fruit per spur after the first drop. This was only one-eighth of the setting at the corresponding time of 1938.

It is clear that fruit setting is a highly variable and unpredictable process, and it is clearly undesirable, if not irrational, to leave it entirely to nature, when it has been demonstrated that very few fruits accomplish the threefold purpose of giving a commercial crop, ensuring blossom bud formation, and greatly promoting vegetative vigour.

Methods of Controlling Alternate Cropping.

The practices that have proved successful for regulating alternate cropping involve the single principle of drastically reducing the blossom or the setting during the effective period. A special instance in which the cropping may be regulated other than by this principle is afforded by the pear variety Winter Cole, which may be made to crop partially on spurs and partially on laterals by a system of pruning which promotes and utilises lateral growth. If spurs alone are depended upon, the variety is a well known alternate cropper. This system is not applicable to the chief alternate-bearing varieties of apples, because they form few or no blossom buds on the spurs of laterals when a heavy crop is being carried on the old spurs. Generally speaking, pruning does not accomplish the desired reduction of blossoms or young setting fruit relative to the foliage as the removal of dormant buds, which are mixed leaf and blossom buds, equally reduces the leaf and blossom. The experiments of Grub[7] indicate that heavy pruning has a slight effect if done before the off year, the explanation of which is obscure. The main function of pruning in this respect is to maintain vigour by reducing the number of growing points to a state of balance with the nutritional conditions.

No cultural practices carried out before midsummer, that is, shortly before the normal time of blossom bud formation, have been found successful for restricting the formation of blossom. All efforts in this direction, at the present time, have as their main objective the maintenance of vigour by generally good cultural practices. The obstacle to devising a practice to affect the number of blossoms is the physiological dominance of the fruit over the vegetative growth. Fertilisers which might be used would be monopolised by the fruit, even if they could be depended upon to be washed into the soil by timely rains.

Pre-drop Thinning. Pre-drop thinning is the practice of drastically reducing the blossom or young fruits during the effective period. As a result of experiment the recommended practice is :

(1) To leave only one fruit to every six spurs throughout the tree.
(2) To commence the thinning as soon as fruit buds can be distinguished at bud-burst, and to complete it by five weeks after the date of full bloom.

This practice has been called " pre-drop thinning ", because it *must* be completed before the natural shedding sets in. Such pre-drop thinned trees will carry about 75 per cent. of a normal crop, and the fruit will be of large or very large sizes.

Practical Considerations of Pre-drop Thinning. Pre-drop thinning is expensive in labour costs ; it takes between one and two hours, depending upon the extent of the excessive setting, to thin a tree by this method, at a cost of, say, 1s. 6d. per hour. Besides, there is a need for exactness, and either the grower must do the work himself or arrange for carefully supervised labour. Further, there are limitations upon time at this season of the year, because of necessary spraying against pests and diseases. The actual time available is a short period between spur burst and calyx sprays, and another period of approximately two weeks between calyx and first-cover sprays. Even to have this time free, fruitgrowers must have their orchard work, especially their spring ploughing, well forward. For these practical reasons, growers have

been advised to concentrate their efforts upon a few trees, such as can be properly handled.

Several advantages completely offset this expenditure and effort :

(1) Pre-drop thinning greatly improves the fruit in size and colour, and hastens its maturity. In open markets the quality of the fruit has commanded a premium which handsomely repaid in the first year the cost of pre-drop thinning.

(2) It improves the vigour of the tree, which is an important point in many districts. Improving the vigour of the tree is an integral effect of the practice.

(3) It should not be necessary to pre-drop thin again until thrips or frost or some other agent upset the regular cropping.

(4) The indications are that the yield from two regular crops will be about 50 per cent. higher than the one on-year crop per biennium.

(5) The losses from the seasonal hazards of hail, drought, etc., are minimised by having regular instead of alternate crops.

Blossom-reducing Sprays. Bearing in mind the time limitations, and recognising the special advantages to vegetative growth of disposing early of the excessive blossoms, blossom reducing sprays are now under trial. As a result of this first season's tests, red oil (4 per cent.) has been discarded, as it does not destroy sufficient blossoms, and causes severe russetting on McIntosh apples. Cresol (1 per cent.) and tar oil (2 per cent.) have proved satisfactory crop reducers in many respects for McIntosh apples, but further experiments are necessary, particularly with dilutions, because of leaf burn, and with other varieties, before any recommendations can be made. The advantages of these sprays either for the direct control of alternate cropping, or as an aid to the work of pre-drop thinning for the same purpose, are obviously great, and their wider use in future is considered to be a distinct possibility.

Summary.

The opportune time to control fruit cropping rests in a period of approximately 35 days following full bloom. Importance is attached to this as the effective period because it is then that are determined the setting of fruit and the mean leaf and shoot growth of the current season, and also whether or not blossom buds will form for next year's crop.

Excessive blossoming and setting, recurring periodically as a general condition, and biennially in biennial varieties, are the chief factors militating against the foregoing growth and development.

New practices have been designed to dispose of excessive blossoming and setting during the effective period. They are, firstly, a rather precise fruit thinning which has been called pre-drop thinning to differentiate it from ordinary fruit thinning ; and secondly, blossom reducing sprays.

References.

(1) Aldrich, W. W. Proc. Amer. Soc. Hort. Sc. 28 : 599-604, 1932.
(2) Aldrich, W. W., and Fletcher, L. A. Proc. Amer. Soc. Hort. Sc. 29 : 56-61, 1932.
(3) Aldrich, W. W. Proc. Amer. Soc. Hort. Sc. 30 : 332-340, 1934.
(4) Bowman, F. T. Ag. Gaz. N.S.W. 50 : 10, 574-5, 1940.
(5) Bowman, F. T. Fruit Cul. and Sm. Farm. N.S.W. 10 : 126, 1940.
(6) Bowman, F. T. J. Pom. and Hort. Sci. (in press).
(7) Grub, N. H. East Malling Res. Sta. Ann. Rept. for 1931 : 61-66, 1932.
(8) Harley, C. P., Masure, M. P., and Magness, J. R. Proc. Amer. Soc. Hort. Sc. 30 : 330-331, 1934.
(9) Magness, J. R., Fletcher, L. A., and Aldrich, W. W. Proc. Amer. Soc. Hort. Sc. 30 : 313-318, 1934.
(10) Paddock, W., and Charles, F. C. Proc. Amer. Soc. Hort. Sc. 25 : 195-7, 1928.
(11) Padfield, C. S. Orch. of N.Z. 13 : 47, 1940.

(Received for publication, 3rd March, 1941.)

Modern Methods of Clearing and Developing Poor Land in South Australia

By

T. H. Strong, M.Sc.Agr.,
Soils Division, C.S.I.R., Waite Research Institute, S.A.

The rational limits of production in areas of low rainfall of South Australia appear to have been reached and, in some cases, exceeded. The story of the over-exploitation of marginal lands is being told today in terms of soil erosion and drift. Much attention has, in consequence, been paid during recent years to the intensive areas of low-grade heath- and scrubland lying within the 15-inch isohyet, which experience a seasonal rainfall sufficient for the requirements of crops or pasture. The area which will be discussed is bounded on the map by the 35° and 36° parallels of South Latitude and extends practically from the coast to the Adelaide-Melbourne railway line. Kangaroo Island is also included. The northern part of the mainland zone, which includes the Fleurieu Peninsula, is referred to as the Hills country, and the southern, from Lake Alexandrina to the 36° line, is referred to as the Upper South-East.

The big problem has been that of soil deficiencies. In addition to the universally low levels of nitrogen and phosphate, it is now apparent that the available copper content of many soils is too low for healthy plant life, and the grazing animal also is affected. Now it appears that these soil deficiencies can be remedied and the land brought into production economically if a judicious system of animal husbandry is practised. The bad practice of cereal cropping upon these soils which are so low in nitrogen is rapidly ceasing, as payable " boom " prices no longer support it, and the after-effects of the system itself are now manifest in their depleted condition and their tendency to drift. The trend is now towards pastoral development with sheep, and suitable legumes play a most important part. Neither the solution of soil deficiencies nor favourable prices for fat lambs and wool would have carried development far, if highly efficient and cheap methods of eliminating natural scrub and cultivating the land had not been evolved. The following discussion directs attention to these aspects, for the system, though originally adapted to a class of country carrying a distinct type of vegetation—mallee—is now being applied to land carrying a comparatively heavy class of sclerophyll scub.

The Class of Land and Past Utilisation.

Much of the early intensive development in this State has been within the zone of red-brown earths where the natural vegetation was a type of savannah woodland. These soils, though they have responded well to superphosphate, were comparatively fertile in their virgin condition and a large area has maintained an exploitative system of agriculture for many years. Intensive cereal production was later extended to the mallee country during periods when prices were favourable. A cheap method of clearing was evolved, the scrub being rolled down with a heavy roller and burnt, before cultivation with specially adapted ploughs of the " stump-jump " type. A succession of cereal crops with grain yields payable at very favourable prices would provide the stubble necessary for running fires to control regrowth of scrub. These methods were successful in zones of the heavier, better class, grey and brown mallee soils, and when cereal prices dropped, mixed farming systems, with sheep husbandry as a mainstay, were introduced. However, many of the mallee soils proved too poor and unsafe even for these methods, while efforts to apply them upon the podsolised soils of the higher rainfall zone invariably failed.

During recent years fresh attempts have been made to develop these poor soils by means of modern machinery and sound principles of pasture development in which legumes play the dominant role in conjunction with proper management of the grazing animal. Certain areas of the Upper South-East of South Australia, the near coastal belt extending from the Adelaide Hills to Victor Harbour, and Kangaroo Island are now being converted to pasture for wool and fat lamb production.

The zone under review can be roughly classed into a number of major categories on the basis of vegetation and climate. In the drier belt true mallee associations prevail, as for example, the *Eucalyptus angulosa-E. diversifolia* type of the Upper South-East, and the *E. rugosa-E. cneorifolia* type of Kangaroo Island. These do not extend far within the 19-inch isohyet. The soils under this class of sclerophyll scrub are typically leached; some, particularly those of Kangaroo Island, are solonised and most of them are developed over limestone. Although acid in the upper horizons, they are suitable for development with lucerne on account of the moderately favourable conditions of the subsoil. On the wetter side of the 19-inch isohyet, true mallee species are no longer prominent, and a stringybark, *E. Baxteri*, is found over a wide area. The typical vegetation of the podsols of the higher rainfall zone up to the 28-inch isohyet is usually a stunted sclerophyll scrub, or sometimes forest. The common association is *E. Baxteri-E. cosmophylla*, and the soils of this zone are mostly lateritic in character. The acidophilous legume, subterranean clover (*Trifolium subterraneum*) is an important factor in the development of these soils. Other soils to be considered are the podsolised deep sands carrying a heath-like vegetation, and the solonised soils of Kangaroo Island which are under stunted narrow-leaf mallee (*E. cneorifolia*) and broombush (*Melaleuca uncinata*).

Apart from the limited areas of soils of better class, including those of the Upper South-East, where a type of savannah with large eucalypts such as *E. camaldulensis* (red gum), *E. ovata, E. leucoxylon* or *E. fasciculosa* is found, and those of the Hills country of Fleurieu Peninsula, covered originally with a sclerophyll forest dominated by the stringybark (*E. obliqua*), the podsolised soils of South Australia have not been very intensively developed until comparatively recent years. There are many reasons, the chief of course being the extremely low fertility of the group. The phosphate level is usually of the order of 0·001–0·01 per cent., and the nitrogen status, as may be anticipated, is correspondingly low. Seasonal drought is a factor limiting development of the vegetation, which is typically sclerophyllous and stunted, and the predominance of certain Proteaceous elements and the grass-tree or yacca (*Xanthorrhoea* spp.) is indicative of low fertility. A second reason is that the dense mass of shrubs, the yacca, and in particular the eucalypts, have proved difficult to clear. Finally, on certain areas partially cleared and growing pasture, stock troubles have often developed. It is because the area as a whole experiences a seasonal period of effective rainfall sufficiently long to grow improved pasture species, that persistent efforts have been made to develop them.

Modern Methods of Clearing.

The methods of clearing the mallee soils of a better class have failed when applied to these soils, because they are too infertile to support a sufficient growth of cereal or grass to give the necessary burns for controlling regrowth. They have first to be cleared by ploughing effectively. The most important modern developments have been in the use of caterpillar tractors with horse-power of the order of 35–50, and the manufacture of ploughs sufficiently strong to stand up to the exacting conditions. The high-powered tractors will pull specially built large, heavy scrub rollers, weighing up to eight tons, and carrying a heavy log superstructure (Fig. 1). This will flatten to the ground a class of scrub in which the eucalypts are up to 10–12 inches in diameter, provided the ground is sufficiently wet for the roots to give way and not too wet for the tractor tracks to grip. The log superstructure on the

roller is important and its height can be adjusted to suit the class of scrub being rolled. When tall trees are being rolled it is an advantage for it to be high so that it will lever the trees over for the roller itself to complete the work of pushing them over. Twenty acres or more of average scrub can be rolled in a full day when the outfit is working efficiently.

After the scrub has been rolled and burnt, and any logs that remain, picked up, the land is ready for the plough, if the soil is not too dry. The " Majestic " disc plough* is the final product of a continuous improvement of the old stump-jump type. The plough has been strengthened in all vital places and the stump-jump principle developed to such an extent that the discs are efficient agents for stump removal. Where once the spring release allowed the discs to " ride " over stumps with comparatively little resistance, they are now so adjusted that they exert a powerful leverage on the stumps before rising or slipping aside. It is still necessary of course for the release principle to act when stumps prove too tough, but a very

Figure 1.

A modern scrub roller in action in scrub of the *E. Baxteri-E. cosmophylla* type with trees up to 10 inches in diameter. The essential features of the roller may be noted. A heavy log superstructure, triangular in shape, resting on a forecarriage about 36 feet from the roller. The heavy log which forms the hypotenuse of the triangle levers the trees over to an angle which allows the roller to " mount " the trunks and complete the process of flattening to the ground. The cleats 3 inches in width riveted to the outside are " staggered ". The Tractor is (43 H.P.) a Caterpillar type.

high percentage of stumps are either turned out of the ground or so loosened that the second ploughing completes the job even in a moderately heavy class of scrub land. When all the tension is applied there is actually 400 lb. pressure on each disc, increasing to 500 lb. as it rises. It is probable that pressures no greater than 100 lb. were actually produced on the old stump-jump types of plough. The jumper arm has naturally to be strong and is made with three 4×1 inch pieces of steel, and the bearings are all of cast steel. The discs themselves are made of $\frac{1}{4}$ inch steel and are usually 26 inches in diameter. The total weight of the plough is $2\frac{1}{2}$ tons. A 45-h.p. tractor will draw two ploughs arranged in series, with a total of 13 discs cutting about nine feet ; 20 acres can be ploughed in one full day.

* " Majestic " is the trade name for the special plough produced by John Shearer & Sons, Kilkenny, South Australia.

The Costs of Clearing Land by Machinery.

It is vital for the success of the clearing operations that the land should be sufficiently wet for ploughing. Although the plough will penetrate to greater depths, a 5–6-inch ploughing is highly effective for eliminating both eucalypts and yacca, provided the soil is not too dry for stumps to give way readily enough. Naturally the costs of clearing and ploughing vary greatly with the class of vegetation which is being handled. In the stunted heath country where the eucalypts are very depauperate, rolling is not always necessary if the standing scrub is first burnt. Rolling may cost up to 12 shillings an acre in typical stringybark country, with the largest trees up to 10 or 12 inches in diameter. Unfortunately the fallen stringybark logs do not always burn well, and the operation of picking up logs prior to ploughing is an additional cost. Two ploughings can be done in the heavy stringybark country usually for less than 20 shillings. This is the normal contract rate, which naturally includes liberal allowance for depreciation. In the heath country one ploughing followed by a cross-ploughing with a twin-disc of "stump-jump" type, cutting twice the width of the former plough, is usually sufficient and costs are correspondingly

Figure 2.
Two "Majestic" disc ploughs attached in series, in action on the same land as shown in Figure 1 after the burn. The disc third from the left is turning a stump out of the ground. Note the strong construction of the jumper arms and the springs they carry.

lowered. The average cost of rolling is 10 shillings per acre. For little more than £2 per acre, land carrying stringybark and cup gum can be cleared effectively and, with a small additional cost of harrowing, be ready for planting. This cost may appear high when compared with the old costs of clearing mallee by firing methods, but it is to be remembered that this land is effectively cleared and a large proportion of the stumps actually removed from the field for this cost. No further fires are necessary after the initial burning of the rolled scrub.

The question arises as to how far these methods can be extended, particularly in the eastern States—Queensland for example—to replace the costly methods of clearing by hand, or to develop a class of land which, though experiencing excellent rainfall, has not yet been brought into intensive agriculture. Admittedly the land which carries vegetation that can be handled by a heavy roller may not be as fertile as that which carries rain forest, but if the costs of clearing can be kept below £3 per acre and the soil deficiencies can be remedied economically—as they can in South Australia—the proposition may become far more attractive from the general economic point of view. The final carrying capacity of the land need not be particularly high if these initial costs can be kept sufficiently low, and, using the methods

outlined, they certainly can be kept low when compared with the costs of clearing by hand. Can the brigalow scrub of the old prickly pear country in S.E. Queensland be dealt with by these methods with suitable modifications? Is there a class of forest country in the more tropical areas which can be handled also? Is all of the "Wallum" country too poor for any such treatment to be successful? Would it prove payable if a suitable system of animal husbandry were introduced? Some experimental work is justified, for the land certainly can be cleared cheaply on an extensive scale, the soil deficiencies can be overcome if the appropriate legume is found, and the rainfall is adequate.

The Deficiencies of the Soil.

It has already been pointed out that the levels of phosphate and nitrogen are extremely low in the soils under discussion. The machinery will produce suitable seed-beds, but the soil deficiencies have still to be remedied. There are two distinct categories into which pasture development falls; in the one the basis is lucerne, and in the other it is subterranean clover. On Kangaroo Island the limits of lucerne are set by the natural distribution of the narrow-leaf mallee (*E. cneorifolia*), for soils supporting this species have typically structured solonised subsoils, alkaline in reaction, with a sufficiently high proportion of exchangeable calcium to make them suitable for lucerne. Where the rainfall is above 20 inches and the vegetation association is dominated by stringybark and cup gum, the subsoil is acid and subterranean clover is the most suitable legume. This latter group of soils is lateritic and, as is usual with this class, is difficult in some respects. Phosphate deficiency is not easily remedied unless particular attention is paid to the time and method of application of the appropriate phosphatic fertiliser.

Although there are many legumes in the natural vegetation such as *Pultenæa*, *Daviesia* and *Platylobium*, they are low-grade nitrogen fixers, and it is doubtful whether their specific nodule-producing organisms will infect the introduced pasture legumes. The first essential is to introduce the appropriate nitrogen fixing bacteria with the legume seed. Successful inoculation is only obtained if certain seed-bed conditions are fulfilled and the phosphate is drilled in, so as to be concentrated with the seed in the drill row. The phosphate status of the soils is too low normally for the nitrogen-fixing bacteria to survive and multiply. Subterranean clover has been used as the pioneer legume in the Hills country for many years, but it cannot be considered altogether satisfactory. On Kangaroo Island it was used in the early trials, but although an excellent stand could be obtained in well prepared seed beds in freshly cleared country, second year regeneration was always disappointing. It has now been proved that the plants will set a good crop of seed only if copper sulphate is added to the soil. The application of small quantities of copper sulphate has made a big difference to the seed-setting of both clover and field peas on Kangaroo Island. Originally, lambs could not be reared on the pastures, but they are thriving now that copper is being administered in the salt lick. Spectrographic analyses of the hydrochloric acid extracts of soil samples have indicated that the chief soil types of the island are extremely low in copper, and the deficiency is widespread. Further evidence that copper is deficient over a wide area of the Upper South-East of South Australia has been obtained from the appearance of "steely" wool in the clips from a number of newly developed holdings. "Steely" is the description applied by officers of the Division of Animal Nutrition of the C.S.I.R. to the wool, lacking in character, which is grown by sheep when their copper intake is inadequate.

The Practice of "Conditioning" the Soil.

Although a good result can be obtained when pastures are put down on a well prepared fallow after the scrub is cleared, the ultimate success is due chiefly to the treatment of the pasture as a crop. There are vital practical and technical points

to observe: the legume must be inoculated, the conditions influencing nodulation must be rendered favourable and, finally, deficient minor elements—copper for example—must be applied in addition to the necessary superphosphate. When an annual legume such as subterranean clover is used in a typically poor area, regeneration in the second season is often disappointing. The soils are so low in phosphate that it is difficult to apply enough fertiliser as a broadcast dressing to be available for normal plant growth. The difficulty is accentuated in those soils which tend to fix or revert superphosphate strongly, particularly as subterranean clover grows best in the presence of the highly soluble forms of phosphate.

The "timing" of the operation of top-dressing is an important factor, but a sound policy of pasture establishment seems to include preparatory soil "conditioning". By "conditioning" is meant the remarkable effect of the grazing animal on the soil, the beneficial effects of urine, excreta and compaction when sheep,* for example, are fed intensively upon an area. This practice, from the economic viewpoint, fits in nicely with fat lamb raising which is at present being widely

Figure 3.

The same area as shown in Figures 1 and 2, three years afterwards. It was sown in the first year to a "conditioning" crop of field peas, and in the second year to subterranean clover with a "nucleus" of perennial grasses for permanent pasture. This photo was taken in the year after this seeding, when the land was carrying three sheep to the acre. Copper sulphate was included in the fertiliser.

practised; it also provides a sound basis for setting down permanent mixed pasture, and enables the problem of soil deficiency to be solved. (Fig. 3.)

The most satisfactory "conditioning" crop so far used has been the field pea. Now that the difficulty of seed-setting has been overcome by the use of copper sulphate, excellent yields—up to 30 bushels per acre—can be obtained on Kangaroo Island on land straight from scrub, provided the planting conditions previously indicated are adhered to. The field pea is being used successfully too as a pioneer in the development of exceedingly low-grade scrubland covered with stunted white mallee and black mallee (*E. angulosa* and *E. diversifolia* association) in the Upper South-East near Lakes Alexandrina and Albert. During the last three years, 250 acres of "worthless" scrub have been "worked up" each year, and sown in the first year to inoculated peas with seven pounds of copper sulphate, and a bag of

* In South Australia sheep are the most satisfactory animals for the "conditioning" process, but it is quite possible pastures suitable for dairying or "baby" beef production will be developed, at least on Kangaroo Island.

superphosphate to the acre. Last year, although less than 15 inches of rain fell, 1,200 lambs were fattened on 250 acres, the values going from 7s. 6d. per head on entering to 21s. (average) on leaving. There is a strong temptation to get some immediate return from land in which the outlay for clearing has been heavy, and this system is an attractive departure from the old overdone system of cereal cropping. After the " conditioning " crop, this land is planted to lucerne under a light seeding of oats as a cover crop. The lucerne pastures obtained by this method are now carrying 2–3 sheep comfortably all the year round.

On Kangaroo Island summer grown field turnips are proving an excellent " conditioning " crop, and they are available for feeding at the bad time of the year. The rotation of peas-turnips-pasture is a promising one, and at present there seems no reason why a rotation of peas-turnips repeated for two seasons before pasture is sown should not give excellent results both from the economic and the pasture viewpoint. By the time the second pea crop is planted the land will be in condition for harvesting, and the farmer would be excused for using the peas as a cash crop to pay expenses, particularly as they are seldom below five shillings per bushel.

Under present war conditions, this constructive work of developing poor land has been interrupted. The necessary machinery has been produced and methods of cropping and management devised for an intensification of the activity in favourable times. Practically the whole of the advance in handling these scrublands of low grade has taken place in the last five years, and without doubt the maximum efficiency has not yet been obtained.

(Received for publication, 10th May, 1941.)

Irradiation of Cheese Moulds and Bacteriophage by Ultra Violet Light

By

W. S. Sutton, B.Sc.Agr.,

Bacteriologist, Department of Agriculture, Sydney.

References to the sterilising effects of rays of ultra violet light are comparatively common. The numerous aspects of investigation include the influence of radiation on moulds[1, 2, 3, 4] as well as bacteria[5, 6] and have established the fact that ultra violet light, generated by numerous designs of machine, is an effective lethal agent against many types of micro-organisms. Research concerning the essential basic principles of ultra violet light generation, output and wave length control has now reached the stage where lamps are being constructed in increasing numbers and serious efforts are being made by manufacturers to popularise their use in industry. In this respect, claims have already been made concerning the satisfactory results obtained in the baking and butchering industries as well as in medical and veterinary fields.

As a Westinghouse " Sterilamp " unit* was available to the author, it was decided to investigate the possibility of the application of ultra violet light in the control of certain adverse biological phenomena in the cheese industry. Two of the outstanding problems which, it appeared, might possibly be investigated with profit were mould growth on ripening cheeses and bacteriophage in " starters."

* Kindly made available by E. F. Wilks & Co. Pty. Ltd., Sydney.

The series of trials recorded below were undertaken with a generating unit in which a single lamp or a series of two, three or four lamps could be employed. The unit was attached to 240 volt A.C. power, the voltage being further stepped up by a built-in transformer. Each lamp was a narrow cylindrical tube, thirty inches long, which contained mercury vapour dispersed in inert gases. No means of measuring the output of ultra violet light nor its wave lengths were available, but in this latter regard the manufacturers claim that 80 per cent. of the radiant energy produced is in the region of 2000–2600 Å.

The experimental results recorded were obtained with a two-lamp set up.

THE MOULDY RIND PROBLEM.

Fungous mycelium, spores and various coloured pigments are developed on the rind of cheese during the curing period ; and although they cause no actual deterioration in quality they detract from the appearance of cheese, thus rendering mouldy specimens less popular with distributing agents. The high degree of correlation between vigorous mould development and abundant moisture in the air makes it essential to hold the relative humidity in the curing room below 70 per cent. if excessive mould growth is to be prevented. Such a precaution, however, is unprofitable as it induces undue evaporation of water from the cheeses and reduces their weight by 7–14 per cent. Accordingly, numerous other methods of mould inhibition have been devised but none of them has completely solved the problem. The following series of tests were therefore undertaken to determine if ultra violet light would destroy mould spores under certain of the conditions likely to be encountered in a cheese curing room.

Effect of Ultra Violet Light on Mould Spores.

Irradiation of Air-borne Mould Spores on Moist Surface. Aseptically poured plates of wort agar were exposed to air-borne contamination and then submitted to ultra violet light for periods ranging from 4 to 16 minutes, the surface of the agar being three inches from the source of light. Platings and exposures were made in duplicate and readings were made after 72 hours incubation at 30° C.

Control plates developed a total of 42 mould colonies whereas 4, 8, 10 and 16-minute exposures gave 14, 17, 14 and 9 mould colonies, respectively. Although there was no very great difference between the numbers of colonies developing on the exposed plates, there was actually a steady reduction in numbers in the 8, 10, 16-minute exposure sequence. All exposures showed a considerable reduction when compared with non-irradiated plates.

Irradiation of Air-borne Mould Spores on Dry Surface. Sterile plates were exposed to the air to permit mould spores to fall on to the inner glass surface. Plates of sterile wort were similarly exposed at the same time. All plates—excepting non-irradiated controls—were then subjected to irradiation for periods of 4, 8, 10 and 16 minutes under the same conditions as in the previous tests. At the completion of irradiation, sterile wort agar was poured into those plates which contained no medium. Mould colony counts were made at the end of 72 hours' incubation at 30° C.

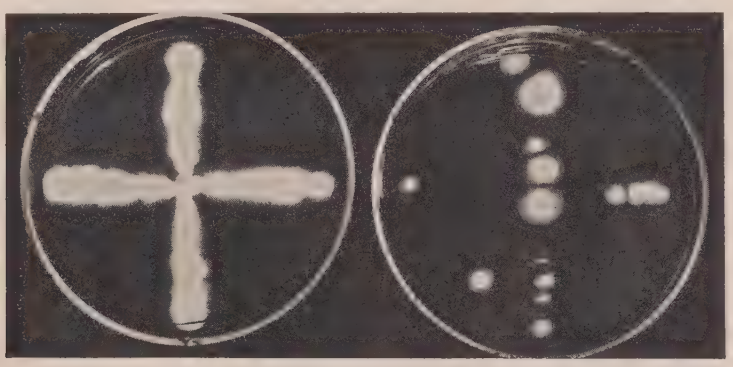
In the non-irradiated plates, 31 colonies developed on the exposed agar surfaces and 30 colonies on the glass surfaces. The sum of the colonies developing on the irradiated agar surfaces was 42, while that from the irradiated glass surfaces was 43. The average colony count per plate was as follows :

Non-irradiated agar surface	5·16
Non-irradiated glass surface	5·0
Irradiated agar surface	1·75
Irradiated glass surface	1·79

It is obvious that there is no important difference in the rate of destruction of mould spores when irradiated on moist and dry surfaces.

Irradiation of Germinating Mould Spores. A series of tests demonstrated that short periods (two to five hours) of incubation on the surface of nutrient medium did not accelerate the destructive action of ultra violet light on mould spores. Longer periods of incubation were next investigated. Spores of *Penicillium* sp. and *Cladosporium* sp. were shaken in tubes containing 2 per cent. cane sugar in tap water and were incubated overnight at 20° C. At the end of the incubation period, nine droplets of spore suspension of each fungus were transferred to each of several plates of sterile wort agar. Each droplet, containing numerous spores, was placed not nearer than half an inch to any other droplet, and any development of mould at the point of inoculation was recorded as growth. Thus no differentiation was made between 1 per cent. and 100 per cent. spore germination in any droplet.

One series of plates was inoculated and treated after a spore incubation period of 18 hours ; at this stage no development of germ tubes was evident. A second series was conducted after 21 hours in the case of Cladosporium, and 24 hours in the case of Penicillium ; in each case germ tubes were abundantly present.



A B

Figure 1.

Showing the inhibitory effect of ultra violet light on germination of spores of *Penicillium* sp.

A. Control plate. B. Spores irradiated at a distance of six feet for 17 hours.

When exposed in the pregermination stage, some spores of both fungi survived 10 minutes' irradiation at three inches. However, several droplets on each plate were completely sterilised. All spores were destroyed by 10 minutes' irradiation in the germination stage.

Irradiation of Moulds of Various Genera. Mould spore suspensions prepared and distributed as in previous tests were irradiated for periods ranging from five minutes to two hours. The genera included Oidium, Penicillium isolated from cheese rind, Hormodendron, Macrosporium, Cladosporium and Aspergillus. There was a distinct difference in resistance of genera ; the susceptibility to destruction being in the order listed above. The Aspergillus, which belonged to the *niger* group, showed development in seven droplets after one hour, and only in one droplet after two hours.

The finding that the dark coloured spores are more resistant than the lighter ones is in conformity with results published from other laboratories.

Irradiation of Penicillium Spores at Various Distances from the Generating Lamp. A newly prepared sugar suspension of Penicillium (isolated from cheese) spores was streaked, in the form of a cross, on the surface of an aseptically poured plate of potato dextrose agar. Replicate plates were irradiated for 17 hours at distances of three inches, one foot and six feet.

Perfect growth occurred in all controls. No growth occurred in plates exposed at three inches or one foot. Growth was very scanty on the plate exposed at six feet.

Irradiation of Masses of Mould Spores. Mature colonies of *Penicillium* spp., *Cladosporium* sp. and *Aspergillus niger* were exposed, at three inches, to irradiation for a period of 24 hours.

When the colonies were brushed with a moist needle and the spores so collected were transferred to the surface of a nutrient slope, abundant growth took place in all instances.

Similar experiments in which spore " dust " was accumulated on glass surfaces and treated under the above conditions also demonstrated the inability of the light to penetrate spore material to any depth of practical importance.

Discussion on Mould Spore Irradiation.

In a cheese curing room, mould spores are normally found floating in the air, resting on the surface of shelves and other fittings, and on the surface of the cheeses themselves. In the first two instances the environment is not moist in the sense that there is obvious free water ; while in the latter case the rind almost always feels damp for the first few days after manufacture. Portion of the above work was designed to determine if either of these conditions was likely to influence the resistance of the spores to the irradiation. The results indicate that there is no important difference in the reaction of the spores in response to variations of humidity likely to occur in the cheese curing room. High relative humidity and the occasional condensation of moisture which might accompany any lowering of room temperature therefore appear to be unlikely to prove limiting factors in the successful application of ultra violet light in cheese factories.

The comparatively high resistance of dark coloured moulds was established. Although they are all susceptible to destruction by irradiation there still exists, theoretically, a stage of treatment where Penicillium would be destroyed and the darker moulds would survive. Such a condition might well prove less desirable than that which prevails at present.

The inability of ultra violet light to penetrate aggregations of spores does not constitute a serious menace to the possibilities of practical control. Provided that treatment in the curing room proves to be efficient against single spores, the necessity to control spore masses will never arise. The data in this respect merely demonstrate that it will be imperative to remove all mouldy cheeses from the room prior to the installation of the ultra violet light generating equipment.

The lessening in lethal effect as the distance from the lamp is increased is in conformity with expectation, but will need to be given careful consideration in the design of units for treatment of cheese curing rooms. The results suggest that a distance of six feet between lamp and area to be treated would approximate the maximum.

One feature which will almost certainly prove to be the major limiting factor in spore destruction is the difficulty which will be experienced in irradiating all surfaces in the curing room. Economic limitations to the use of sufficient lamps to penetrate all positions may necessitate the installation of reflectors and the daily rotation of cheeses. That the latter precaution may prove to be successful is indicated by

Imperial Chemical Industries of Australia and New Zealand Limited

aims to provide primary industries with new and efficient chemicals and formulations. Our products are thoroughly tested by Research Departments as chemical entities before appearing on the market commercially.

A NEW PREPARATION

is now being marketed under the registered trade mark of:

CUPROX

This easy-to-use copper fungicide spray has been developed to supersede Bordeaux and Burgundy mixtures. It is composed of Redispersible copper oxy-chloride and provides economical and efficient control of diseases against which Bordeaux and Burgundy are effective.

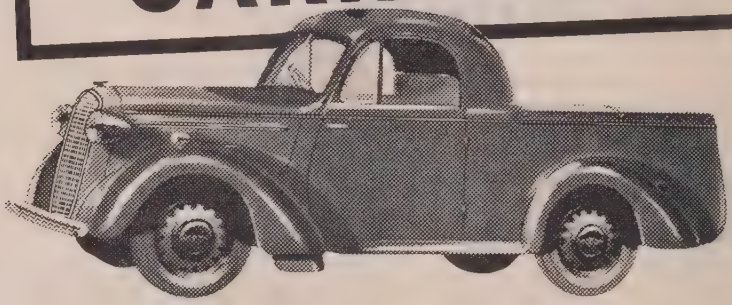
For further information write:

IMPERIAL CHEMICAL INDUSTRIES OF A. & N.Z. LIMITED

376/380 Collins Street, Melbourne

or Local Distributors.

Cut your delivery costs *with the* Economical Roomy CARRYALL



7 BODY STYLES

In seven body styles . . . Open, Wellside and Flareboard Deliveries, with Coupé or Roadster front. Also a big capacity Panel Van.

You get real economy with the Bedford 6 cwt. Carryall. The 10 h.p. Overhead Valve Engine power gives the economy of over 40 miles per gallon. Add to this its longer wheelbase, wider track, bigger body, and those features you associate with Bedford—six-phase carburettion, Independent Front Wheel Springing, Hydraulic Brakes and Synchromesh Gears, and you will realize that the Bedford Carryall is engineered to surpass any other Utility on the road. Call in to-day and inspect the Bedford 6 cwt. Carryall.

GENERAL MOTORS—HOLDENS LIMITED

BEDFORD 6 CWT. CARRYALL

BUY FROM YOUR LOCAL BEDFORD DEALER

Sold and Serviced by Bedford Dealers throughout Australia.

For
high strength,
shock- and
wear-resistance,
specify . . .

NI-TENSYL-IRON

Ni-Tensyl-Iron is a nickel cast iron with a tensile strength of 22-25 tons per square inch. Because of this high strength combined with uniformity of properties, it may be used to save weight or cost by replacing more expensive materials such as steel. Its uniformity applies throughout variations of section and it is suitable for both large and small castings. By heat-treatment the strength of Ni-Tensyl-Iron may be increased to 35 tons per square inch with a Brinell Hardness Number of 302, at which figure it is still quite machinable.

Full information on Ni-Tensyl-Iron is given in our publication B25 — write for a free copy.

WE WILL GLADLY REPLY TO ENQUIRIES REGARDING ALLOY CAST IRON FOR SPECIFIC PURPOSES

WRIGHT & COMPANY 41 Clarence Street, SYDNEY, N.S.W.

HAWKER, RICHARDSON & Co., 209 William St., Melbourne

HARRIS, SCARFE Limited, Grenfell Street, Adelaide.

best for farm and all outbuildings..

Employ "Durabestos" (asbestos-cement) Building Sheets for permanent resistance to rodents and white-ants. The rigid sheets afford weather-tight protection without painting; they are easily cut, nailed and fixed. Sold by builders' suppliers in your locality.

Manufactured by Wunderlich Limited (established 52 years), Crown and Cleveland Sts., Sydney.

WUNDERLICH DURABESTOS

SOW SHILLINGS . . . REAP POUNDS

A.M.P. Life Assurance gives you the chance of building up for yourself, by small instalment payments, a "Retirement Fund" payable at an age chosen by yourself. If you should die before reaching that age the assurance would be paid to your representatives.

SHILLINGS—
that you'd not miss, for

BENEFITS—
you can't afford not to have.

A.M.P. SOCIETY

Head Office:
87 PITT STREET, SYDNEY

A. W. SNEDDON, F.I.A.,
General Manager and Actuary.

the data which show that the rate of destruction of germinating spores is more rapid than that of the spores in a quiescent state. Thus periods of 24 hours in shaded areas, although they may permit the germination of spores, will not necessarily encourage the growth of mycelium on the surface of the cheese.

Arrangements have been made to test the efficiency of ultra violet light in controlling mould growth on cheese rinds under factory conditions at the Hawkesbury Agricultural College.

THE BACTERIOPHAGE PROBLEM.

Bacteriophage active against lactic-acid-producing streptococci is often present in cheese making vats. Its action frequently retards the rate of acid production and sometimes completely arrests it. Serious trouble is also caused when phage attacks the bulk "starter" and destroys all the bacteria it contains.[7]

The ultimate origin of starter bacteriophage has not been definitely established, but it has been clearly demonstrated that it may be disseminated through the air.[8] Methods of phage control, in addition to the usual routine of factory hygiene, have aimed at insulating starter propagation technique from the environment of phage infested air. Owing to the chemical nature of bacteriophage it seemed possible that irradiation with ultra violet light might prove an effective means of destroying its lytic activity and thus eliminating sudden unpredictable changes in vitality.

Effect of Ultra Violet Light on Bacteriophage.

Irradiation of Bacteriophage in Thin Films of Whey. Phage whey quantities of 2 ml., 4 ml. and 9 ml. were measured into sterile petri dishes of standard dimensions. They were then exposed to irradiation at a distance of three inches from the source of light for six minutes. Samples were withdrawn at intermediate intervals. The samples, which were approximately 1-200 ml. quantities, were placed on agar plates smeared with an appropriate streptococcus and the preparations were examined for lysis after incubation at 30° C. for 24 hours. Three strains of phage were used in each determination.

All phages in all quantities of whey survived treatment for at least two minutes, at the end of which period all phages in 2 ml. of whey had been inactivated. In the case of 4 ml. of whey, the phage was protected for 4-minute periods. The phage in 9 ml. quantities was completely destroyed in six minutes. All three phages were equally susceptible to the effect of irradiation.

Irradiation of Droplets of Phage-Whey. Small droplets (approximately 1/200 ml.) of phage-whey were picked up on a rounded platinum loop and exposed, with steady rotation, to treatment for varying periods of time.

Complete destruction of phage occurred in four minutes.

Irradiation of Phage-Whey for Short Periods. Four ml. quantities of phage-whey in petri dishes were irradiated, at a distance of three inches, for periods of one, two and three minutes. One ml. samples were then withdrawn and diluted in quarter-strength Ringer's solution in powers of 10 to 10^{4}. Loop samples were withdrawn at each stage of dilution and placed on the surface of agar plates smeared with susceptible streptococci. Three phages were treated.

In every case the titre of the whey was reduced to 1/100 of its original strength during the first minute of exposure. However, no further destruction, detectable by this technique, occurred during the following two minutes.

Ageing of Irradiated Phage-Whey. Samples irradiated and diluted under conditions similar to those of the above test were held at approximately 20° C. and tested for phage titre on each of four days immediately following irradiation.

There was no variation in phage titre in any dilution during four days' storage of the irradiated material.

Irradiation of Dry Phage-Whey. A drop of phage-whey from a 2 ml. pipette was placed on the centre of a sterile coverslip in a sterile petri dish. It was then dried at 37° C. for four hours, irradiated at a distance of three inches for 30 seconds, redissolved in a drop of sterile quarter-strength Ringer's solution and a droplet transferred to a plate-smear of appropriate streptococci. Controls included undried non-irradiated drops, undried irradiated drops and dried, redissolved drops.

Both the non-irradiated and the irradiated undried samples caused complete lysis of the area covered by the droplet. There was a tendency for the dried non-irradiated material to lose portion of its lytic properties. This slight though not very appreciable reduction was evidenced by the fact that the edges of the lysed areas were not clearly defined and showed ingrowths of bacterial cells. The 30 seconds' irradiation of the dried material reduced the lysed areas to scattered plaques in all three phages tested.

Irradiation of Phage Inoculated Starter. To test the effect of ultra violet light on starters and bacteriophage in starters a series of 500 ml. beakers, containing approximately 200 ml. of milk, were prepared. All were inoculated with a pure strain of *Streptococcus cremoris* and a suitable phage was added to half the series. Irradiation was at a distance of three inches from the surface of the milk. Non-irradiated beakers were placed in the unit side by side with irradiated beakers, but the milk surface was screened by petri dish lids. Samples treated for one hour were permitted to remain in the unit but were screened by petri dish lids at the end of their exposure period. All samples were titrated for acid formation at the end of 24 hours from the time of inoculation. The temperature of the milk was approximately 30° C. Table 1 summarises the results obtained.

TABLE 1.

The Effect of Ultra Violet Radiation on Acid Formation by Pure Strains of Streptococcus cremoris *in the Presence of Bacteriophage.*

Starter Strain.	Phage Strain.	Per cent. Lactic Acid Developed After Irradiation for		
		0 Hour.	1 Hour.	24 Hours.
Nil	Nil	0·19	0·19	0·19
Sur 1	Nil	0·76	0·78	0·56
Sur 1	Sur 1	0·42	0·44	0·37
Sur 2	Nil	0·81	0·77	0·50
Sur 2	Sur 2	0·38	0·38	0·34
HP	Nil	0·72	0·74	0·51
HP	HP	0·41	0·40	0·35

Ultra violet light is incapable of destroying bacteriophage in milk cultures of *Streptococcus cremoris* and has no serious effect on the activity of the bacteria for a period of at least one hour. Twenty-four hours' continued irradiation of starter in milk caused a definite decrease in the rate of acid formation.

Discussion on Bacteriophage Irradiation.

Little has been published on the effect of ultra violet irradiation of bacteriophage, and in one instance[9] the presence of peptone was stated to protect the phage from destruction. The results of the writer's experiments indicate that streptococcal

bacteriophage active against certain lactic-acid-producing strains can be destroyed in thin films of whey or in whey dust by irradiation by light from the Westinghouse " Sterilamp " unit.

The destruction of bacteriophage on the utensils in a factory is a relatively simple matter, and an outline of the routine of factory control has already been published.[10] It has also been shown[11] that hypochlorite, almost universally employed in milk product plants, is the most effective of the common disinfectants in destroying bacteriophage.

The problem of phage control in cheese factories thus becomes particularly a problem of air sterilisation, and the above tests have established that ultra violet light may be an effective means of accomplishing this end. Phage probably floats in the air entrapped in whey dust or suspended in droplets of moisture. In both cases it is susceptible to destruction. It would therefore appear that irradiation of the starter preparation room might prove a valuable means of purifying the air in the immediate vicinity of the bulk starter. The possibility would still remain that phage dust entering the room or arising from the clothes of the operator during the starter propagation process would escape destruction.

The fact that even short periods of irradiation destroy a considerable proportion of the phage is an encouraging feature in regard to irradiated rooms. It would probably mean that a certain percentage of starter failures would be eliminated but it would not completely eliminate the trouble, nor even prevent the occasional occurrence of phaging in its most extreme form.

The utilisation of " irradiation hoods " designed to fit closely over the starter can, and to prevent air currents and clothes' dust contacting the can, is suggested as an effective means of eliminating failure of bulk starter due to lysis by bacteriophage. Field scale experiments will shortly be undertaken to test the practical utility of such a device.

SUMMARY.

Ultra violet light effectively destroys moulds and streptococcal bacteriophage under some of the conditions likely to be encountered in cheese factories.

There is a possibility that mould growth on the rinds of maturing cheese may be prevented by irradiation, while it is highly probable that the incidence of starter failure would be greatly decreased by the installation of effectively designed starter " irradiation hoods ".

References.

[1] Fulton, H. R., and Coblentz, W. W.: Jour. Agr. Res., 38: 159-168, 1929.
[2] Grampoloff, A. V.: Rev. Appl. Mycol., 17: 418, 1938.
[3] Hollaender, A., and Emmons: Rev. Appl. Mycol., 18: 737, 1939.
[4] Gier, L. J.: Rev. Appl. Mycol., 18: 46, 1939.
[5] Gates, F. L.: Jour. Gen. Physiol., 13: 231-260, 1930.
[6] Sharp, D. G.: Jour. Bact., 39: 535-547, 1940.
[7] Whitehead, H. R., and Cox, G. A.: Jour. Dairy Res., 5: 197-207, 1934.
[8] Whitehead, H. R., and Hunter, G. E.: Jour. Dairy Res., 12: 63-70, 1941.
[9] Kendall, A. I., and Colwell, Charlotte: Rept. Proc. 3rd Internat. Cong. for Microbiol., p. 298, 1939.
[10] Sutton, W. S.: Aust. Milk and Dairy Products Jour., Feb., 1941, pp. 9-12.
[11] Hunter, G. J. E., and Whitehead, H. R.: Jour. Dairy Res., 11: 62-66, 1940.

(Received for publication, 5th May, 1941.)

Internal Grain Infection in Maize

DUE TO *GIBBERELLA FUJIKUROI* AND *GIBBERELLA FUJIKUROI* VAR. *SUBGLUTINANS*

By

E. T. Edwards, Ph.D., M.Sc.Agr.,

Plant Pathologist, Department of Agriculture, Sydney, N.S.W.

Introduction.

Surveys made in various parts of the world since 1920 have shown that commonly maize seed samples are infected internally with one or more of a number of micro-organisms and that frequently the incidence of infection is high. The writer[2] has shown that in New South Wales the most prevalent internal seed-borne organisms in maize are *Gibberella fujikuroi* (Saw.) Wr., *G. fujikuroi* (Saw.) Wr. var. *subglutinans* Edwards, *Cephalosporium acremonium* Corda, and *Penicillium* spp. *Diplodia zeae* (Schw.) Lev. and *Gibberella zeae* (Schw.) Petch rarely occur internally in sound grain although both are fairly common as ear-rotting organisms. It has been found also that internal grain infection with *G. fujikuroi*, or *G. fujikuroi* var. *subglutinans*, is commonly responsible for defective germination and the development of pre-emergence and seedling blight diseases.

The present investigations were carried out at the University of Wisconsin, U.S.A., during the tenure of a Commonwealth Fund Service Fellowship and were designed to furnish some further information on the factors responsible for the development of internal grain infection with *G. fujikuroi* and *G. fujikuroi* var. *subglutinans*.

In addition to the work reported herein an extensive survey was made of the 1938 American maize crop to ascertain if there was any regional correlation between the incidence and identity of the fungi causing kernel rot and those occurring internally in sound grain. The results of this survey have been published elsewhere.[3]

The factors affecting fungous infection of maize ears have been studied by several workers. Boewe[1] investigated the relation of husk coverage to ear rot development in Illinois maize over a period of several years. Koehler[4] studied inoculation methods and the most critical infection periods for *Diplodia zeae*, *Gibberella zeae*, *G. fujikuroi*, and *Nigrospora sphaerica* and subsequently[5] investigated ear rot development in relation to time of planting; he also[6] investigated the mode of ear infection with *G. fujikuroi* and *Cephalosporium acremonium*, and later[7] made an extensive laboratory study of the relation between moisture content of grain and the growth of various ear-rotting fungi. Koehler, Dungan and Burlison[8] conducted germination tests with grain at different stages of maturity, and obtained data on the stage of development at which grain became infected with different organisms under field conditions. Manns and Adams[9] discussed the possibility of internal grain infection occurring directly through the silks and kernels, or by systemic infection through the shank. Pole-Evans[10] found that ear-rot infection with *Gibberella zeae* and *Diplodia zeae* may occur at any time during growth, either through the silks or the husks, but that wounds were necessary for infection with *G. fujikuroi* and *G. fujikuroi* var. *subglutinans*.

The writer[2] has reported the results of ear infection experiments in which a high degree of internal grain infection with *Gibberella fujikuroi* var. *subglutinans* was established by several methods of inoculation. In 1935-36 preliminary evidence

was obtained that little if any internal grain infection with *G. fujikuroi* or *G. fujikuroi* var. *subglutinans* could be established as a result of inoculating maize ears in the late stages of maturation and development. In the fall of 1937 the possibility of establishing internal infection in nearly mature ears of maize was investigated more fully at the University of Wisconsin, and in the summer of 1938 inoculation experiments were conducted at the University Farm, Madison, in an attempt to determine the relation between time of inoculation and the incidence of internal seed-borne infection with these two organisms.

Infection Studies.

Laboratory Inoculation Experiments with Mature Ears. In early October, 1937, a number of mature and apparently disease-free ears of open pollinated Golden Glow maize were selected in the field at Madison, Wisconsin. The ears were examined carefully in the laboratory in order to exclude any which showed traces of ear rot, and 25 grains were removed spirally from each of the ears finally selected. These grains were surface sterilised in alcohol and mercuric chloride and after thorough washing in sterile water the tip portion of each kernel was removed aseptically and transferred to potato dextrose agar plates to determine the nature and incidence of any naturally-occurring internal seed-borne infection in each ear.

Forty apparently sound ears were selected and treated in this way. They were then placed on wire trays in a large humidity chamber and maintained in a very moist atmosphere at a temperature of 25-27° C. for three days. At the end of this period 20 ears selected at random were again sampled, and the samples plated to determine if the period spent in the humidity chamber had influenced the nature or incidence of internal seed-borne infection.

Twenty of the ears were then sprayed thoroughly with a heavy aqueous spore suspension of *Gibberella fujikuroi* and the remainder were similarly inoculated with *G. fujikuroi* var. *subglutinans*. The two isolates used in these experiments were known to be pathogenic on maize, as they were identical with the isolates used by the writer[2] in previous work.

The two lots of inoculated ears were placed in separate chambers and maintained for an additional period of four days in a moist atmosphere at 25-27° C. This temperature was known to be near the optimum for spore germination and mycelial growth of the isolates used as inoculum. Immediately after removal from the inoculation chambers an additional sample of 25 grains was removed spirally from each ear for subsequent isolation work. All the experimental ears had thus been maintained in a warm moist atmosphere for a period of seven days—three days prior to inoculation and four days after inoculation.

Results of Mature Ear Inoculations. Isolations made from the grain removed from the ears at time of selection showed a low incidence of natural internal fungous infection, as 71 per cent. of the grain remained sterile and only three ears showed more than 25 per cent. total infection with *Gibberella fujikuroi*, *Cephalosporium acremonium* and *Penicillium* spp. The effects of incubation and inoculation on the incidence of internal grain infection in the treated ears are shown in Table 1.

Maintenance of the ears at high temperature and humidity for the initial period of three days had no apparent effect on the development of internal grain infection. Examination of the isolation results from the inoculated ears shows that at the end of the experimental period, with one exception, there was a slight increase in the incidence of each fungus that was present internally in the grain at the commencement of the experiment. These results indicate that maintenance of the ears for a period of seven days under environmental conditions particularly favourable for fungous development causes a slight increase in internal seed-borne infection. A

critical examination of the data concerning Gibberella infection indicates that the increase in its incidence at the end of the experimental period was largely independent of inoculation. In the case of *G. fujikuroi* the inoculated ears showed an apparent infection increase of 14 per cent., but there were no reliable means of determining the precise effect of inoculation as the isolate used for inoculum could not be differentiated with certainty from the type of *G. fujikuroi* that occurred naturally in the ears.

In the case of the ears inoculated with *G. fujikuroi* var. *subglutinans* the degree of infection with this fungus increased from nil to two per cent. This increase apparently resulted from inoculation since none of the 40 ears showed any natural infection with this fungus and, moreover, the strain used for inoculation could be

TABLE I.

The Nature and Incidence of Internal Seed-borne Infection in Mature Ears of Golden Glow Maize Before and After Inoculation with Gibberella fujikuroi *or* G. fujikuroi *var.* subglutinans.

Nature of Infection.	Incidence of Infection.					
	20 field selected ears.	The same 20 field selected ears after 3 days in moist chamber at 25–27° C.	20 ears before inoculation with *Gibberella fujikuroi.*	The same 20 ears after inoculation with *G. fujikuroi.*	20 ears before inoculation with *G. fujikuroi* var. *subglutinans.*	The same 20 ears after inoculation with *G. fujikuroi* var. *subglutinans.*
	%	%	%	%	%	%
No infection	81	74	71	44	72	61
G. fujikuroi	7	8	14	28	5	16
G. fujikuroi var. *subglutinans*	—	—	—	—	—	2
Penicillium spp. ..	5	3	6	8	9	5
Cephalosporium acremonium	2	3	2	4	4	9
Miscellaneous fungi ..	—	2	—	2	2	3
Bacteria	5	11	8	16	8	4

identified with reasonable certainty after re-isolation. It is significant, however, that the 20 ears in this series showed an increase of 11 per cent. in the amount of infection due to *G. fujikuroi.* It is obvious that this increase was independent of inoculation, and it very strongly suggests that the corresponding increase of 14 per cent. infection in the other series of ears was also largely, if not entirely, independent of inoculation.

An examination of the data for individual ears showed that in the series inoculated with *G. fujikuroi,* seven of the ears showed infection with this organism prior to inoculation, and twelve of them showed infection afterwards. None of the ears inoculated with *G. fujikuroi* var. *subglutinans* showed infection with this fungus prior to inoculation, but five ears were found to be infected subsequently. It is probable that the slight increases in internal grain infection which occurred in the ears used in these experiments were mostly due to the further development of organisms that had already effected a partial penetration into the kernels prior to the time of inoculation. The results obtained with *G. fujikuroi* var. *subglutinans,* however, indicate that a very slight amount of internal infection may occur in nearly mature ears which have been maintained for some time under conditions particularly favourable for fungous development. Under ordinary field conditions, however, it is improbable that this type of infection is of any importance. It is worthy of mention also that during the period the ears were in the moist chambers there was a profuse development of *Penicillium* spp. on the butts and tips of many of the ears, and yet this fungus likewise failed to become prevalent as an internal seed-borne organism.

Field Inoculation Experiments. During the summer of 1938, ear inoculation experiments with *G. fujikuroi* and *G. fujikuroi* var. *subglutinans* were conducted on open pollinated Golden Glow maize at University Farm, Madison, in order to determine the stage of ear development which was most favourable for the establishment of internal seed-borne infection. It was hoped also that the inoculated ears would provide a supply of heavily infected kernels for use in subsequent studies on the relation of internal infection to seedling blight diseases.

Five series of inoculations were made on ears at different stages of maturity. Each series consisted of 10 ears inoculated with *G. fujikuroi*, 10 ears inoculated with *G. fujikuroi* var. *subglutinans*, and 10 control ears.

At each date of inoculation care was taken to select ears which appeared to be of uniform maturity. Prior to inoculation the tips of the ears were opened by laying back the husks for a distance of about 1-1½ inches, and in addition four longitudinal incisions were made in the husks with a sharp scalpel. The incisions were made at approximately equal distances around the ear and in general extended from the tip to near the base. As far as possible, care was taken to avoid undue injury to the grain. The silks and the husks were then sprayed thoroughly by means of an atomiser with a heavy aqueous spore suspension, and a pad of absorbent cotton wool thoroughly saturated with water was placed over the upper surface of the basal region of each ear and secured in position by means of a small rubber band. A strong paper bag was then placed over each ear and securely tied around the base with a piece of fine wire to which was attached the identification tag.

The inoculated and control ears received identical treatment except that the controls were sprayed with sterile water instead of inoculum. In each series the controls were treated first, and were located at some distance from the corresponding inoculated ears. Likewise the ears inoculated with *G. fujikuroi* were never adjacent to those inoculated with *G. fujikuroi* var. *subglutinans*, as it was desired as far as possible to avoid any admixture of inoculum arising from wind-blown spores.

All ears in the experiment were inspected periodically throughout the growing season and whenever necessary, the paper bags were replaced in order to ensure that the ears remained covered and thus protected from outside sources of inoculum.

The dates of inoculation and the relative stages of ear maturity for each series were as follow:

Series 1. August 9: Ears just pollinated and silks still green.
Series 2. August 10: Five or six days after pollination.
Series 3. August 19: Twelve to fifteen days after pollination.
Series 4. August 30: Grain at dent stage.
Series 5. September 12: Grain nearly mature.

When the ears were harvested during the second week of October, it was found that a considerable amount of kernel rot had developed in both the control and inoculated ears of the first four series. In view of this development it was thought that a considerable amount of internal infection may also have developed from the same source of inoculum. It was decided therefore to select from the same field a number of ears which were well covered with husks and which showed no external symptoms of ear rot, and to use these ears as an additional check on the results obtained from the infection experiments. Accordingly about 70 ears were selected and after a thorough examination to ensure that they showed no macroscopic symptoms of infection of any kind, their number was reduced to 50. The material available for biological examination thus consisted of 50 ears of each of the three treatments together with the 50 ears of apparently sound grain selected at the end of the season.

In all subsequent procedures, each ear was treated as an individual unit. Each ear was shelled by hand, and the number of sound and rotted grains on each was determined by actual count. Isolations were then made from both the rotted and

sound kernels on every ear. The procedure adopted with the rotted grain was to plate 50 kernels whenever they were available, but in cases where the total infection did not involve this number, then all the kernels were plated. Prior to plating, all

Figure 1.

Ears of Golden Glow maize from field infection experiment. Treated 12-15 days after pollination.

Left: 2 control ears.

Centre: 2 ears inoculated with *G. fujikuroi*.

Right: 2 ears inoculated with *G. fujikuroi* var. *subglutinans*.

samples of rotted grain were surface sterilised by immersion for five minutes in a 1 : 10 aqueous solution of B.K. (a proprietary compound containing 3·5 per cent. sodium hypochlorite). All plates were incubated at 25° C. and readings were taken 4-5 days after plating.

The samples of sound grain were treated in essentially the same manner, except that the period of immersion in B.K. solution was increased to 15 minutes, and in all cases only the tip or embryo end of the grain was plated following its removal aseptically, after the whole grain had been removed from the sterilising solution. Isolations were made from 50 sound kernels from each ear and the infection records were made after 5-6 days' incubation at 25° C.

Figure 2.

Ears of Golden Glow maize from field infection experiment. Treated at nearly-mature stage of development.

Left: 2 control ears.

Centre: 2 ears inoculated with *G. fujikuroi*.

Right: 2 ears inoculated with *G. fujikuroi* var. *subglutinans*.

Results of Field Inoculation Experiments. The effect of inoculation on the development of kernel rot and internal grain infection is shown in Table 2. It will be seen that a considerable amount of kernel rot occurred in both control and inoculated ears of each series except the last. In nearly all cases the infection was restricted to localised areas in the vicinity of wounds made during treatment. Ears showing the typical effects of treatment at the pre-dent stage and at the nearly mature stage of development are shown in Figs. 1 and 2.

A high degree of internal grain infection occurred in all ears treated prior to denting. Inoculation at the dent stage also caused a high incidence of internal infection, but the incidence in the control ears was considerably lower than in the controls treated at earlier stages of development. Inoculation at the nearly mature

TABLE 2.

The Effect of Inoculating Ears of Golden Glow Maize at Five Different Stages of Maturity with Gibberella fujikuroi *and* G. fujikuroi *var.* subglutinans. *Madison, Wisconsin,* 1938.

Series.	Treatment.	Total Number of Grains.	Kernel Rot.	Apparently Sound Grain.		Relative Incidence of Fungi Causing Kernel Rot and Internal Grain Infection.					
						Kernel Rot.			Internal Infection.		
				Free from Infection.	Internal Infection.	*G. fujikuroi.*	*G. fujikuroi* var. *subglutinans.*	Miscellaneous.	*G. fujikuroi.*	*G. fujikuroi* var. *subglutinans.*	Miscellaneous.
			%	%	%	%	%	%	%	%	%
1	Control	5781	20·4	7	93	49	33	17	39	15	47
	G. fujikuroi	4459	13·1	12	88	80	3	17	74	3	24
	G. fujikuroi var. *subglutinans*	3917	23·1	4	96	19	81	—	9	80	10
2	Control	4912	15·3	17	83	63	12	25	64	7	29
	G. fujikuroi	5882	7·0	9	91	80	1	19	84	1	15
	G fujikuroi var. *subglutinans*	4691	15·1	8	92	—	99	1	3	90	8
3	Control	4963	23·8	11	89	60	15	25	51	31	18
	G. fujikuroi	4645	14·4	8	92	94	3	2	82	2	16
	G. fujikuroi var. *subglutinans*	4661	12·4	6	94	—	100	—	—	95	5
4	Control	4940	8·5	45	55	31	13	56	44	5	51
	G. fujikuroi	5361	10·1	18	82	98	—	2	82	—	18
	G. fujikuroi var. *subglutinans*	5699	17·5	20	80	—	97	3	4	90	7
5	Control	6346	0·7	74	26	53	16	31	19	16	64
	G. fujikuroi	6686	2·6	43	57	86	—	14	81	2	16
	G. fujikuroi var. *subglutinans*	5810	4·5	27	73	—	85	15	19	45	36

stage caused very little kernel rot and also less internal infection than in any other series.

The precise effect on internal grain infection of inoculation with *G. fujikuroi* and *G. fujikuroi* var. *subglutinans* at different stages of ear maturity is shown diagrammatically in Fig. 3. This chart is based on the actual recorded incidence of each organism in the control and inoculated ears of each series and not on the relative percentages given in Table 2.

The high incidence of infection in the control ears indicates clearly that at time of treatment the ears were contaminated heavily with Fusaria and other organisms that were capable of inducing both kernel rot and internal grain infection following the opening of the ears and their subsequent maintenance in the particular environmental conditions that existed within the covering bags. In every instance miscel-

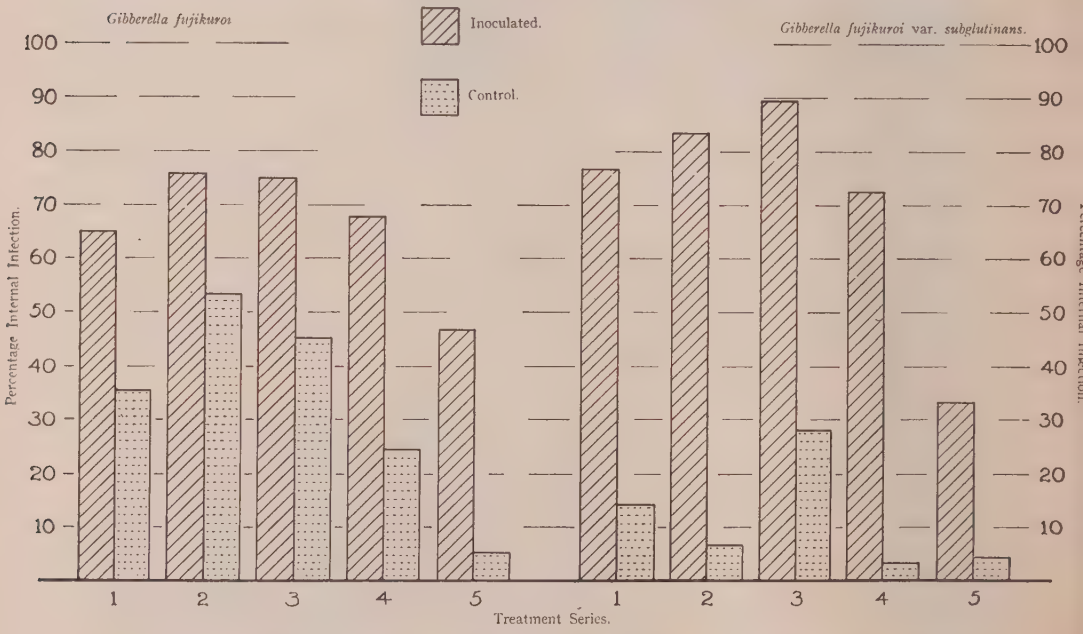


Figure 3.
The incidence of internal grain infection with *Gibberella fujikuroi* and *G. fujikuroi* var. *subglutinans* in inoculated and control ears of Golden Glow maize treated at five different stages of maturity. Madison, Wisconsin, 1938.

laneous fungi were responsible for a considerable proportion of both the kernel rot and internal infection that occurred in the control ears. These fungi included several types of unidentified Fusaria, *Gibberella zeae, Nigrospora sphaerica, Penicillium* spp., *Aspergillus* spp. and *Trichoderma viride. Cephalosporium acremonium* was fairly common as an internal seed-borne organism but was not isolated from rotted grain. The cultures of *G. fujikuroi* isolated from the control ears showed considerable variation in mycelial growth, colour production and other cultural characters, thus indicating that a number of different strains were present. Several distinct cultural types of *G. fujikuroi* var. *subglutinans* were likewise obtained from the controls.

The isolates obtained from the inoculated material were generally very uniform in character and the predominant type of *G. fujikuroi* compared remarkably well with the isolate used as inoculum. The ears inoculated with *G. fujikuroi* var.

subglutinans in every instance yielded the most uniform cultures and these, with few exceptions, appeared to be identical with the isolate used as inoculum.

The high incidence of internal infection occurring in both the control and inoculated ears is in marked contrast to the very low incidence of this type of infection which occurred in the 50 apparently sound ears that were selected at maturity in the field. Isolation from 2500 grains of this material (50 kernels taken at random from the shelled grain from each ear) showed that 83·0 per cent. of the grain was free from infection, 4·2 per cent. infected with *G. fujikuroi*, 1·4 per cent. with *G. fujikuroi* var. *subglutinans*, 0·2 per cent. with *Fusarium* spp., 3·4 per cent. with *Cephalosporium acremonium*, 5·7 per cent. with *Nigrospora* spp. and 2·1 per cent. with other fungi and bacteria. Only 24 per cent. of these ears were infected with *G. fujikuroi* and in only three cases did the infection involve more than 20 per cent. of the kernels. *G. fujikuroi* var. *subglutinans* occurred in grain from 22 per cent. of the ears, but in no case did infection with this organism exceed 20 per cent. These ears were collected from the same part of the field as that in which the infection experiments were located and it can be assumed that they were subjected essentially to the same degree of natural contamination as were the experimental ears prior to bagging. It would appear therefore that the cutting of the husks and the subsequent maintenance of the ears in a moist atmosphere were the important factors in enabling infection to become established.

The isolation results obtained from the individual experimental ears showed that ears infected with kernel rot caused by *G. fujikuroi* or *G. fujikuroi* var. *subglutinans* always showed a high incidence of internal grain infection likewise due to these organisms. It must not be assumed, however, that ears free from kernel rot will therefore be free from internal grain infection as abundant evidence is available to show that ears which are apparently sound in every respect, nevertheless may be infected very heavily with one or more internal seed-borne fungi.

Summary.

(1) Laboratory inoculation experiments showed that little if any internal grain infection with *Gibberella fujikuroi* or *G. fujikuroi* var. *subglutinans* could be established in mature ears of maize even under conditions highly favourable for fungous growth.

(2) The maintenance of mature ears of maize in a warm moist atmosphere for seven days caused a slight increase in the incidence of naturally occurring internal grain infection due to *G. fujikuroi* and other organisms.

(3) Field infection experiments showed that a high incidence of internal grain infection due to *G. fujikuroi* and *G. fujikuroi* var. *subglutinans* could be established by inoculating the ears at all stages of maturity from the time of pollination up to the nearly mature stage.

(4) The highest incidence of infection was obtained by inoculating the ears between pollination and the dent stage of development.

(5) Injury to the husk and the maintenance of the ear in a moist atmosphere for some time afterwards were important factors in enabling infection to become established.

(6) Ears treated in this manner at any time between pollination and the dent stage of development also showed a considerable amount of kernel rot.

(7) Kernel rot infection with either *G. fujikuroi* or *G. fujikuroi* var. *subglutinans* rarely developed unless the grain had been injured.

Acknowledgments.

The writer is indebted to Professor J. G. Dickson of the University of Wisconsin and to Dr. D. H. Bowman, formerly Research Assistant in the Department of Plant

Pathology, for the conduct and supervision of the field infection experiments during the writer's absence from Madison; to the Commonwealth Fund of New York for the provision of a special grant for technical assistance; to Mr. L. Plzak, formerly of the College of Agriculture, for assistance with the grain counts and the isolation work; and to Mr. Eugene Herrling of the Department of Plant Pathology for the photographic work.

References.

(1) Boewe, G. H.: Ill. Nat. Hist. Survey Div. Pub. No. 273, 19 pp., 1936.
(2) Edwards, E. T.: N.S.W. Dept. Agr. Sci. Bull. 49, 68 pp., 1935.
(3) ———: Jour. Aust. Inst. Agr. Sci. 6: 25-31, 1940.
(4) Koehler, B.: Ill. Agr. Expt. Stat. 43rd Ann. Rept., 51–52, 1930.
(5) ———: Ill. Agr. Expt. Stat. 44th Ann. Rept., 55–56, 1931.
(6) ———: Phytopath., 26: 98–99, 1936.
(7) ———: Jour. Agr. Res., 56: 291–307, 1938.
(8) Koehler, B., Dungan, G. H., and Burlison, W. L.: Jour. Amer. Soc. Agron., 26: 262–274, 1934.
(9) Manns, F. T., and Adams, J. F.: Jour. Agr. Res., 23: 495–524, 1923.
(10) Pole-Evans, I. B.: Farming in S. Africa, 12: 546, 1937.

(Received for publication, 15th May, 1941.)

TECHNICAL NOTES

RESPONSE TO ZINC ON A SOUTH AUSTRALIAN SOIL.

In 1938 a report appeared in this Journal (Vol. 4, p. 41) indicating the marked response to copper by plants growing on the calcareous soils at Robe, in the coastal area of the south-east of South Australia. Responses have been shown by a great number of cereal and pasture species. It was observed, however, that most species still gave yields much lower than could be expected under the particular conditions of climate, even when heavy dressings of copper sulphate (up to 112 lb. per acre) had been applied in addition to liberal quantities of phosphorus, potassium, nitrogen, and several other elements. Furthermore, the appearance of the indicator plants, oats, wheat and barley, was not always normal.

Further investigations with Mulga oats at the field station of the Council for Scientific and Industrial Research at Robe in 1939 showed that, in the presence of applied copper, the addition of zinc sulphate increased the grain yield considerably. This increased grain production was at the expense of the straw. The trial was one of a series carried out on a loose sand-dune area, which accounts for the low yields obtained. The yields are shown in the following table:

Treatment per Acre.	Yield per Acre. Grain (bush.).	Straw (cwt.).
Copper sulphate 56 lb.	10·6	20·9
Copper sulphate 56 lb. plus zinc sulphate 28 lb.	18·0	15·1
Standard error	±1·46	±3·60

Subsequent field experiments carried out during 1940 have confirmed these results, and some excellent crops and pastures have been obtained by the addition of zinc to the superphosphate-copper sulphate fertiliser. Details of these later investigations will appear as a pamphlet of the Council for Scientific and Industrial Research.

D. S. Riceman,
Animal Nutrition Laboratory,
Adelaide, S.A.
A. J. Anderson,
Waite Research Institute,
Adelaide, S.A.

(Received for publication, 20th February, 1941.)

SOME COMMON INSECTS OF LUCERNE IN NEW SOUTH WALES.

Field collecting was carried out by the writer in various districts situated in each of the following regions: (*a*) the Hunter Valley, (*b*) the coast from Windsor to the Macleay River, (*c*) the Central Tableland division (Bathurst, Mudgee), (*d*) the inland slopes of the Tableland from Gundagai north to Gunnedah, and (*e*) the Riverina (Wagga, Leeton, etc.). The work was done during the first three months of 1940, and from September, 1940, to the end of April, 1941.

By the completion of this survey certain insect species, by their frequency of occurrence, their wide distribution and general prevalence, had impressed the writer as being outstanding and typical elements of the lucerne fauna of New South Wales. The species which meet this description have been listed in Table 1, which omits a number of insects* that appear very unlikely to have any agricultural significance in lucerne.

Each species in Table 1 has been found in numbers in many widely scattered localities, and each was noted as " very abundant " in at least one crop of lucerne. Moreover, every species was collected in several months of the year and most of them have been found in lucerne accompanied by their larvæ. These facts together suggest that lucerne crops are a normal habitat, if not a breeding ground, for the species listed.

TABLE 1.
Insect Species in Lucerne—First Order of Frequency and Abundance.

Species.	Known Distribution.	Species.	Known Distribution.
**Megacoelum modestum* Distant	H C T S R	*Melanopthalma australis* Blkb.	H C T S R
Campylomma livida Reut.	H C S R	A small brown Otitid fly species	H C T S
**Nabis capsiformis* Germ.	H C T S R	**Zizeeria labradus labradus* Godart	H C T S R
**Mirperus scutellaris* Dallas	H C T S R	**Heliothis armigera* Hb.	H C T S R
**Nysius vinitor* Berg	H C T S R	**Tortrix divulsana* (Walk.)	C T S
**Œchalia schellembergi* Guerin-M.	C T S R	**Chlorochlistis laticostata* Walk.	S R
†*Empoasca terra-reginæ* Paoli	H C T S		
†*Nehela torrida* Evans	C T S	**Bruchophagus* sp.	C T S R
†*Thamnotettix argentata* Evans	C T S R	*Apis mellifera* L.	H C T S R
		Various Thysanoptera, Ants, Wasps and Spiders, their identity and range undetermined.	
Coccinella repanda Thun.	H C T S R		
Laius bellulus Guer.	H C T S R		

C = Coastal division
T = Central Tableland
S = Slopes division
R = Riverina
H = Upper Hunter Valley
} Regions of N.S.W.

† Adults of these three Jassid species are usually accompanied by larvæ; identity of larvae not checked.
* Larvæ, as well as adults, of these insects are sometimes found in lucerne.

Table 2 includes a number of species showing a high order of prevalence in New South Wales lucerne but which did not impress the writer as being entirely outstanding in geographical range, consistency of occurrence and abundance in crops. All of these species belong to groups which include insects of economic importance.

TABLE 2.
Insect Species in Lucerne—Second Order of Frequency and Abundance.

Species.	Known Distribution.	Species.	Known Distribution.
‡*Chortoicetes terminifera* Wlk.	H S	‡*Piezodorus hubneri* Gmelin	T S R
‡*Baryopadus* (*Leptops*) *nr. squalidus* Boh.	H		
Alesia frenata Erichs.	C S	*Mutusca brevicornis* Dallas	C T S
Scymnus notescens Blkb.	C S R	*Dictyotus coenosus* Wwd.	H C T S R
‡*Pantomorus leucoloma* (Boh.)	H C S	*Cermatulus nasalis* Wwd.	H T
‡A brownish Delphacid 4 mm. long	T S	*Eurinoscopus punctatus* Evans	C T S
Paniscus sp. nr. *ephippictus* Sm.	C S	‡A brown Mirid, heavily patterned	C T S

‡ These species were often abundant in the crops they infested.

* E.g., various Nematocera, Plectoptera, higher Diptera and several species of moths which appeared to be merely casual visitors to the crops.

In addition, the field collections of 1940-41 included a number of other species quite commonly met with in lucerne. Though sometimes abundant, their degree of prevalence did not appear to justify their inclusion in Tables 1 and 2.

Certain of these unlisted species are of some economic interest and are discussed below, (i) to (iv).

(i) *Pantomorus tæniatulus* (Berg.). Heavy infestations of this South American weevil occur in crops at Lochinvar and Windsor ; like *P. leucoloma* (above), its larvæ feed heavily upon the tap-root of lucerne.

(ii) *Nezara viridula* L. In the whole survey only one individual of this once abundant pest was taken. Its scarcity may be due to the presence of *Microphanurus basalis* Woll., introduced into N.S.W. in 1935–36.

(iii) In addition to *Eurinoscopus punctatus* Ev., and the three Jassid species † in Table 1, there are at least three unidentified species of Jassids which infest lucerne in parts of N.S.W.

(iv) At Cowra the mealybug, *Steatococcus nudatus* (Maskell), was found infesting a lucerne plant severely affected with witch's broom virus. This Coccid also infests lucerne in the Armidale district.

Beneficial Species. The predaceous Hemiptera (*Nabis capsiformis, Œchalia schellembergi, Cermatulus nasalis*) and the Coccinellids (*Coccinella repanda, Alesia frenata, Scymnus notescens*) have already been mentioned. A large range of parasitic Hymenoptera was taken in net sweepings, which may account for the high incidence of parasitism often observed amongst caterpillar populations in lucerne. Several species of parasitic wasps and flies were bred from immature stages of Lepidoptera listed in Table 1. Spiders presumed to be beneficial were very numerous in the top growth of many crops. Damsel-flies (Zygoptera) were abundant in many crops but other general predators (Neuroptera, Carabs, Asilids, etc.) seemed weakly represented.

To supplement the field survey of 1940–41, careful search was made through the collections of the Entomology Branch for specimen material in which lucerne was named as the host plant. This study incidentally gave information on the insects of lucerne in the winter months, which period was not covered by the field survey. Some of the specimen material is worthy of record, viz. :

(*a*) *Sminthurus viridis* L. This was found attacking lucerne at Harefield (near Junee) in 1936 and at Tumut in 1939. It has also infested subterranean clover at Holbrook, Tumut, Walbundrie and Brocklesby.

(*b*) *Katianna tasmaniensis* Wom. and *Bourletiella arvalis* Fitch. These Sminthurids were collected in lucerne at many places in the Hunter Valley (1931). The former species was also present at Campbelltown.

(*c*) *Penthaleus major* Dugès. Seedling lucerne crops were destroyed by this mite at Nemingha, near Tamworth, in 1938.

(*d*) Cerambycid larvæ of unknown species, from three districts on the slopes ; labels indicate that they were boring into the crown of the taproot. An adult of the Cerambycid *Corrhenes paulla* Germ. was labelled " from larva in lucerne root ". (The writer collected adults of this species in lucerne on the Upper Hunter last year.) There is some reason to believe that these borer larvæ occur chiefly in stands killed by drought and overgrazing.

(*e*) The collection at the Entomology Branch has specimens of *Persectania ewingi* Wwd., from Maitland (1926) and a series of *Euxoa radians* Gn. bred from cutworms attacking lucerne in the same district in 1930.

Neither of these Noctuid species was taken in the field survey of 1940–41. With the exception of *Heliothis armigera* the Noctuids are apparently not prevalent

in lucerne, though larvæ of *Plusia chalcites* Esp. were fairly abundant in a crop at Bellbrook in February, 1941.

For their determination of various specimens, the writer wishes to thank Drs. J. W. Evans and K. H. L. Key and Messrs. A. Musgrave, K. C. McKeown, G. M. Goldfinch and E. H. Zeck.

C. R. Wallace.

Entomology Branch,
Department of Agriculture,
Sydney.

(Received for publication, 15th May, 1941.)

OCCURRENCE OF ERGOT IN QUEENSLAND, WITH SPECIAL REFERENCE TO *CLAVICEPS PUSILLA* CESATI.

The occurrence of ergot on a number of native grasses in Queensland has previously passed unnoticed, with the exception of two collections of the sphacelia stage by students of the University of Queensland (J. L. Groom, *Digitaria longiflora*, 1936; R. F. Langdon, *Eriochloa pseudacrotricha*, 1937). During May and June, 1940, a number of grasses in the Brisbane, Boonah, Gatton and Beaudesert districts of south-eastern Queensland were found infected by ergot, and further observations during the summer of 1940-41 have added several more species to the list of ergotised grasses, the latter being from the Eastern Darling Downs and Brisbane. To date, 13 native species have been found ergotised in the field, while two others have been inoculated artificially and found susceptible. The susceptible species are: *Dichanthium sericeum, Bothriochloa decipiens, B. intermedia, Bothriochloa* sp., *Cymbopogon refractus, Heteropogon contortus, Themeda australis, Sorghum leiocladum, Ischæmum australe, Eriochloa pseudacrotricha, Eriochloa procera, Eriochloa* sp., *Digitaria longiflora, Brachiaria whiteana,* and *Capillipedium spicigerum.*

Sclerotia from *Dichanthium sericeum* collected around Boonah in May, 1940, germinated during October, 1940, and the species was determined as *Claviceps pusilla* Cesati, which had been described in 1861 from material collected in northern Italy on *Bothriochloa ischæmum.* As far as can be ascertained, there is no mention of *C. pusilla* in the literature, apart from Cesati's original description, and this is apparently the first occasion on which germination of the sclerotia has been observed during 80 years. It is proposed that *C. pusilla* should be known as Blue Grass Ergot since it was on Queensland Blue Grass (*Dichanthium sericeum*) that the species was rediscovered. This is in conformity with the common names for other ergots, e.g. paspalum ergot, ergot of rye.

A determination of the species of Claviceps affecting most of the other hosts has not yet been possible, since morphological characters of the sphacelia stage cannot be used for that purpose. But a comparison of the size and shape of the conidia from the various hosts with those of *C. pusilla* from Dichanthium does give some indication of the species of ergot affecting these other hosts. The conidia of *C. pusilla* are 10–15·5 μ long, 5–7·5 μ broad, hyaline, granular, sometimes biguttulate. In outline they vary considerably, some being elliptic, others curved. Of the latter, some are straight on one side with the other side sharply curved, making the conidia appear 3-sided. An examination of the conidia from other ergotised species shows that they are all similar in size and shape to those from Dichanthium. If the sclerotia which have been collected from eight of the ergotised species germinate this year, they will provide a useful test of the value of conidial characters for specific determinations of ergot.

Germination of Sclerotia of *Claviceps pusilla.*

Sclerotia collected on *Dichanthium sericeum* during the last week of May, 1940, were kept dry in the laboratory until the 5th August. They were then divided into

two groups, one being placed on the surface of moist sand in a petri dish covered with the lid, the other being given cold treatment in a domestic refrigerator for 31 days at 4·5° C. and placed on moist sand on the 9th September. Germination was first observed on the 24th October, when two sclerotia in the group not subjected to low temperatures and four of the refrigerated group were found germinating. Subsequently 20 out of 24 in the latter group germinated but only two out of 12 in the former group developed. Usually only one stroma, but in some cases two or three stromata, were produced by a sclerotium, the average time for development of the stroma to maturity being 14 days. In a few cases production of a second stroma was delayed until after the first had matured, and since germination of individual sclerotia began over a period of three weeks, ascospores were being produced during five weeks. An infection period of this length would probably ensure some plants being in flower while ascospores were being produced.

Inoculation Experiments.

During the past summer, plants of those species known to be ergot-susceptible have been transferred to the author's garden in Brisbane, for the purpose of determining by inoculation experiments the host range of *C. pusilla*, the possible existence of biologic strains of that fungus, and the host range of any other ergots that may later, by germination of the sclerotia, prove to be species other than *C. pusilla*. Conidia of *C. pusilla* produced in culture on potato—10% sucrose—agar and natural conidia have been used for inoculations. So far this fungus has been found to infect *Bothriochloa decipiens* and *Capillipedium spicigerum*, while the ergot of *Eriochloa pseudacrotricha* infects also *Eriochloa procera* and *Brachiaria whiteana*. The flowering habits of the various species under test have to be considered in making inoculations, since only by spraying on the conidial suspension when the glumes are wide open can one be certain that inoculum is reaching the point of infection, which, according to Kirchhoff (1929), is at the base of the ovary.

The times of flowering of some species make it difficult, or even impossible, to make inoculations while the glumes are open ; in some cases manipulation of the glumes with a needle and dropping in inoculum from a fine pipette is possible, and *Bothriochloa decipiens* has been successfully infected in this way. With *Heteropogon contortus* this method involves great damage to the spikelet, but experiments with a hypodermic syringe, now in progress, seem likely to be satisfactory.

Origin and Distribution of Ergot in Queensland.

Although the presence in Queensland of the ergots reported here has not previously been known, there is evidence that *C. pusilla* has been in Queensland for at least 30 years. In the herbarium at the Plant Pathology Section of the Queensland Department of Agriculture is an ergotised specimen of *Bothriochloa decipiens* which is infected also with the saprophytic fungus *Cerebella inquinans*. Conidia from this specimen, which was collected near Brisbane in 1912, are similar in size and shape to those of *C. pusilla*, and there is little doubt that they belong to this species. Of the other species recently found ergotised, there is evidence from the records of the occurrence of Cerebella on *Heteropogon contortus* and *Themeda australis* in 1890 (Bailey, 1890) that the ergots of these two species have been here for 50 years. On the evidence at present available—its restriction to grasses native to Queensland, and its long standing in Queensland of at least 30 years—*C. pusilla* is regarded as indigenous, being the first indigenous species of Claviceps reported from Australia. Having regard to the localities from which it is known, namely, Italy and Queensland, it is probable that this ergot is widely distributed. Some at least of the sphacelia diseases known in Africa, India and south-eastern Asia may be due to it.

Claviceps pusilla is known at present from the Beaudesert and Brisbane districts, Lockyer Valley, Fassifern Valley and eastern Darling Downs ; but there is no reason

for supposing that it does not occur in many other districts—e.g. the Maranoa Burnett and Callide areas, where host plants of this ergot are to be found. Ergot of Heteropogon is known to occur as far north as Bowen, and ergot of Themeda as far north as Gladstone. There has been no opportunity to search for the others in any areas more than 100 miles from Brisbane.

Economic Importance of the Disease.

The ergot hosts reported in this paper include some important native pasture grasses. Some of these are at present under consideration in Queensland for use in marginal Rhodes grass areas where a rather low-fertility-demanding species is required. Any scheme of plant improvement or of seed production must therefore take into account the susceptibility to ergot of many native grasses. Resistant strains are required, as several worthless but widely distributed species may act as sources of inoculum for more valuable species.

The possibility of stock being poisoned by ergot-infected grasses cannot be overlooked, and an explanation of stock losses from unknown causes in past years may possibly be found here.

R. F. Langdon.

Biology Department,
University of Queensland.

Bailey, F. M.: Synopsis Q'ld. Flora, 3rd Supplement, 1890.
Kirchhoff, H.: Centralbl. Bakt., II Ab., Bd. 77, 310-369, 1929.

(Received for publication, 9th April, 1941.)

The Australian Institute of Agricultural Science

MEETINGS OF COUNCIL.

At the meeting of Council held on 27th February in the Victorian Department of Agriculture, Mr. Rowland Hill was admitted to corporate membership. Council considered that the Publications Committee might investigate further economies with a view to holding Journal costs at the 1940 level. The financial statement showed a balance at bank of £250 1s. 7d. on 27th February, 1941.

At the March meeting the Hon. Treasurer reported that grants to Branches on the basis of 5s. 6d. per corporate member had been paid. Financial statement showed a balance at bank of £127 9s. 9d. on 20th March, 1941. Messrs. Cleveland Son & Hislop, of Melbourne, were reappointed auditors of the Institute accounts for 1940.

MEETINGS OF BRANCHES.

New South Wales Branch.

The main business of the April meeting was an address by Dr. E. G. Hallsworth, Lecturer in Agricultural Chemistry, University of Sydney, upon "British Agriculture and its Wartime Problems". After a statement of the food situation in Britain at the opening of the war, the lecturer discussed the materials and methods that were being developed for greater self-sufficiency. In 1938, the agriculturists of the United Kingdom, or "Inner Britain", produced 43 per cent. of the total meat, 34 per cent. of the total dairy produce, 51 per cent. of the eggs, 20 per cent. of the wheat, 94 per cent. of the oats, 95 per cent. of the potatoes, and about 20 per cent. of the sugar. Of the imported balance, only part came from Empire countries, or "Outer Britain", namely, 10 per cent. of the chilled beef, 66 per cent. of the frozen beef, 77 per cent. of the frozen mutton and lamb, 15 per cent. of the bacon and hams and eggs, and 50 per cent. of the butter. As a large part of the foreign imports of pig meat, butter and eggs came from countries which have now fallen under German domination, one main objective of British agriculture has been to increase the production of foodstuffs for livestock, no less than one-quarter of them having been imported previously. The authorities began to foster agriculture nearly three years before the

outbreak of the war, and considerable increases in the advisory staffs were made. Since the arable land was already in a state of comparatively high fertility, the greatest expectation was from grassland. Its principal deficiencies, those of lime and phosphates, could be produced at home, and a subsidy was paid to the extent of one-half of the cost of the lime and one-quarter of the cost of slag used for pasture improvement.

Victorian Branch.

On the 7th March, Associate Professor G. L. Wood addressed members on " The Prospects for Primary Production—an Essay in Prophecy ". Dr. Wood said that the rural producer was being forced into a system based on the power to make war, a thing for which he was least fitted, instead of a system based on peaceful production. National security apparently depended on the ability of a country to wage war successfully. State intervention in agriculture was not new, stated Dr. Wood, in fact the Emperor Wu in China 2,000 years ago took vigorous action against profiteers and confiscated one-twentieth of their fortunes. In modern communities there was a change from a society based on agriculture to one dominated by large-scale factory interests. In war time the farm became less important than the factory. The solution of the problems of primary production lay in the solution of world trade problems. The methods of control were similar in all countries and consisted of credit expansion, pooling of production and organisation of distribution. It would only be possible to deal with the difficulties of primary producers if a nation adopted a policy that made conditions of primary production less unpleasant. Subsidies produced a vicious spiral.

Mr. O. H. Gepp gave an address on the 28th March, entitled " Through the Looking Glass ". After discussing the future of agriculture and its relation to the markets problem, Mr. Gepp advocated increased migration of Nordic types after the war, preferably those with a good industrial background. He said the future of the country and of agriculture depended on increased population, and although he might be accused of deserting agriculture, he felt that the nation would benefit by turning more to the export of secondary products. There were fears that agricultural population and production could not be increased, but this was not so.

At the annual meeting on 9th May, the retiring President (Mr. W. B. Miller) gave an address on " Payment for Quality in Agriculture ", which will be published later in this Journal. The newly-elected President is Mr. G. W. Leeper.

Other Branches.

The annual meeting of the South Australian Branch was held in March, when Dr. A. R. Callaghan was elected President for 1941. Col. G. D. Shaw addressed the meeting on " Civil Defence in South Australia ".

The annual general meeting of the Western Australian Branch was held in April, Mr. F. L. Shier being elected as the new President. The retiring President then delivered an address on " A Review of Merino Sheep Husbandry in W.A."

The annual meeting of the Queensland Branch was held in March, when Mr. J. H. Smith was elected President for 1941. In his retiring presidential address, Mr. C. S. Christian discussed certain aspects of pasture improvement, with special reference to Rhodes grass pasture.

The annual general meeting of the Tasmanian Branch was held in December last, when Mr. J. T. Armstrong was elected President for 1941. The retiring President (Mr. R. A. Sherwin) then spoke on agricultural problems in war time.

Current Notes and News

New Under Secretary of Agriculture, W.A.

Mr. G. K. Baron-Hay, M.C., B.Sc.Agric., Superintendent of Dairying in the Western Australian Department of Agriculture, was last month appointed Under Secretary for Agriculture in the W.A. Department, succeeding Mr. L. St. J. Jones, who has entered on leave prior to retirement.

Mr. Baron-Hay was born in the West Indies in 1895, and was educated at Kingswood School, Bath, England. He came to Western Australia as a student at the Narrogin School of Agriculture in 1913. He was one of the first two students to enrol at the University, then in Irwin Street, in the newly created Faculty of Agriculture. He enlisted as a private in 1916, serving with the 51st battalion, and was awarded the Military Cross in France. After graduating B.Sc.Agric., he was appointed Agricultural Adviser in the wheat branch in 1922. With the development of the group settlement scheme, he transferred to the dairy branch in 1924, rising to the position of Superintendent of Dairying in 1930.

In announcing the appointment last month, the Minister for Lands and Agriculture (Mr. F. J. S. Wise) said : " During his nineteen years in the department, Mr. Baron-Hay has been closely associated with the agricultural development of the State, particularly along the Great Southern and in the South-west districts. He has built up a reputation for far-sighted, fair and

sound thinking, his advice being sought by those engaged in many phases of agriculture. It is believed that the associations which Mr. Baron-Hay has made in the eastern States during the last three years as Western Australia's representative on the Standing Committee of Agriculture, together with his professional training and attainments, will enable him to bring a sound judgment to the administration and co-ordination of the many activities of the Department. I believe that the appointment will meet with the approval of all rural professional and administrative interests. There are very few sections of public life with which Mr. Baron-Hay has not come into contact, and I feel sure that the administration of the Department will be in very safe hands during his term as Under Secretary."

Conference on Plant Quarantine.

A conference of Commonwealth and State officers was held at Canberra in the offices of the Department of Health during 28th April-1st May, for the purpose of reviewing all matters connected with the organisation and administration of foreign plant quarantines. This conference was called at the instance of the Australian Agricultural Council, and was the third of its kind held in this country since the institution of the Commonwealth system of plant quarantine. Dr. J. H. L. Cumpston, Director-General of Health, addressed the conference at the outset, Mr. E. MacKinnon (Director of Plant Quarantine) then occupying the chair throughout the proceedings. Other representatives attending the meetings were Dr. B. T. Dickson and Dr. J. Nicholson (Canberra); Mr. C. G. Savage, Dr. H. J. Hynes, Mr. T. McCarthy and Mr. J. N. Whittet (N.S.W.); Mr. J. M. Ward and Mr. S. Fish (Vic.); Mr. A. G. Strickland (S.A.); Mr. R. Veitch and Mr. H. Barnes (Q'lnd.); Dr. J. W. Evans (Tas.); and Mr. H. R. Powell (W.A.).

The plant quarantine report prepared last year by the Australian Institute of Agricultural Science provided the basis for discussion at the outset, and proved extremely helpful. Various other matters suggested by the State departments for consideration were dealt with, and finally 26 resolutions were adopted by Conference for transmission to the Australian Agricultural Council. It was generally agreed that the deliberations had served to clarify the issue in many important respects, and it is confidently expected that most—if not all—of the resolutions passed will prove acceptable to the Council for implementation.

Research Station for Soil Conservation in N.S.W.

The first Soil Conservation Research Station in Australia was officially opened on 22nd February at Cowra, before a large gathering of landholders of the central and southern districts and representatives of such public bodies as the pastures protection boards and shire councils. On the station, which is some two miles from Cowra, and is 240 acres in extent, the administrative block is now complete and investigational work already well advanced.

The chief field research work is embodied in a series of thirty plots, all enclosed and equipped with concentration flumes, H-type measuring flumes, silt collection tanks, divisor boxes and final collection tanks. The soil specialist is recording the infiltration rates of water on undisturbed soil of differing water content and physical structure, this information being chiefly to facilitate the design of erosion structures, such as contour banks, pasture furrows, drainage outlets, grass waterways, vegetated spillways and, in special circumstances, mechanical structures of concrete, stone or timber. In the forestry and pasture nurseries the plants likely to be of value in erosion control are being examined.

Practically, erosion control will be based upon the correct use of the land and of vegetation. The station will be developed so that high rocky areas are under timber, intermediate lands under permanent pasture, with by-pasture furrows, and lower lands under such cultural systems as crop rotation, strip cropping, contour banks and grass waterways. As much of the rainfall as possible is being absorbed, and the surplus is being led along safely graded and vegetated waterways to a large dam, which now occupies the site of a former maze of gullies. Excess water from the dam will be led along a widely graded and grassed spillway to a permanent creek. In all, the movement of water over the station should be under control from top to bottom.

AGRICULTURE

Illustrated Booklet on Mineral Deficiencies.

The Chilean Nitrate Educational Bureau, Inc., of New York, has published a very useful booklet of 54 pages dealing with mineral deficiencies in crop plants. The publication is devoted almost exclusively to a photographic reproduction in natural colour of minor element deficiencies in such crops as apples, peaches, grapes, citrus, soybeans, tobacco, cotton, cereals and various vegetables. There are, in all, 96 pictures, and each was taken in the field, several of the illustrations being made available to the publishers by the Soil Research Laboratory of the North Carolina Agricultural Experiment Station. At a time when interest is centred in so many quarters on deficiency problems, this publication is a welcome addition to plant pathological literature, and on account of the excellent colour work will doubtless be extensively used for diagnostic purposes.

Personal Notes

Sir David Rivett has been elected a Fellow of the Royal Society of London.

Dr. H. C. Trumble has been appointed Professor of Agronomy in the University of Adelaide.

Dr. Irvine A. Watson has rejoined the staff of the Faculty of Agriculture, Sydney University, after spending two years at Minnesota, U.S.A., where he secured the Ph.D. degree.

Mr. C. M. Donald, Pawlett Scholar, recently returned from England and U.S.A. and spent a period at Sydney University before resuming duties with the C.S.I.R. at Canberra.

Mr. A. A. Lee has been seconded from the Victorian Department of Agriculture as Chief Agricultural Officer to the Flax Production Committee, Department of Supply and Development.

Mr. I. M. Tulloh has been appointed Principal of Longerenong Agricultural College (Vic.). He has been closely associated with the College for over 30 years, first as student, then as Field Officer in charge of the experimental work, and since 1922 as Farm Manager.

Mr. F. S. J. Newman has resigned from the position of Dairy Technologist in the Victorian Department of Agriculture, and is now proprietor of a dairy products factory at Penola, South Australia.

FERTILIZER *for*

the FARM
the ORCHARD
the MARKET GARDEN
the PLAYING FIELDS
the HOME GARDEN

A fertilizer for every purpose—in bulk for commercial use, and in handy packets for the home gardener. We make a wide range of mixtures of Superphosphate, Sulphate of Ammonia, and, where necessary, Potash, that will meet your needs whatever they are. A copy of our price list is available for the asking, and we welcome enquiries for information.

SHIRLEYS & SULPHIDE FERTILIZERS

AUSTRALIAN FERTILIZERS LTD. (Inc. in Vic.), 5 Macquarie Place, SYDNEY.

SCIENCE AND SEEDS

The fruits of scientific research are ever accessible to those who wish to partake. Pasture improvement, which really means higher yields, is only one of the ways in which growers have benefited. But their efforts are in vain if the seedsmen from whom they obtain their seed do not heed the importance of the latest developments.

Modern machinery for cleaning and "washing" agricultural seed is vitally necessary if the sample is to be up to standard. The grower must have this backing in his efforts and, realising this, we have installed the very latest in seed-cleaning plant.

If, therefore, you wish to "partake fully of the fruit" make sure that you obtain reliable seed, expertly grown and scientifically cleaned.

We will gladly send free and post free a copy of our book "Grassland and Green Crop Farming" to all who ask for it.

ARTHUR YATES & CO. PTY. LTD.

SEED GROWERS, SEED MERCHANTS AND NURSERYMEN

184-186 SUSSEX STREET, SYDNEY

FOR STOCK WATERING AND IRRIGATION

Use

"FIBROLITE" PRESSURE PIPES

Combine every advantage of Long Life and Low Cost. Easily and quickly laid by unskilled labour. Free from rust and corrosion . . . maintain high discharge capacity . . . keep pumping costs permanently low.

Sizes 1¼" to 15". Write for illustrated pamphlet.

JAMES HARDIE & COY. PTY. LTD.
CNR. YORK AND BARRACK STREETS, SYDNEY
And at Newcastle, Melbourne, Brisbane, Perth, Auckland

R & W Veterinary Vaccines

ENTERO-TOXAEMIA

Anatox Vaccine 21/- per 500 doses.

BLACK DISEASE

ANATONE Vaccine 26/- per 500 doses.
Both alum precipitate concentrated to 2 c.c.

One Dose per Season

APPROVED C.S.I.R. FLY DRESSINGS

C.B.E. Camphor Oil and Boric acid base.
B.T.B. Coal Oil and Boric acid base.

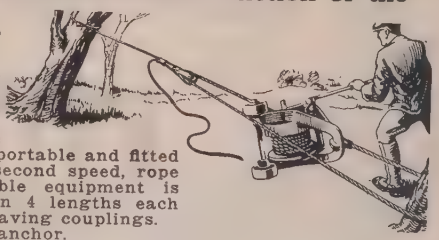
Highly efficient formulæ for the better control of fly-strike.

Also Jetting Compounds.

G. Teesdale Smith Scientific Utilities Pty. Ltd.
The Grace Building **77 York Street, Sydney**

Getting Rough Jobs Done is the Whole Function of the

'Monkey' Grubber



In the "Monkey" Grubber way clearing work is done expeditiously and without great outlay, leaving land ready for mechanical tilling.
The machine delivers 260 times the power applied to the handle. It is portable and fitted with an automatic lowering gear, second speed, rope shortener, snatch block, etc. Cable equipment is generous and comprises 180 feet in 4 lengths each fitted with special labour and time-saving couplings. Takes an acre and a half from an anchor.

TREWHELLA BROS., PTY. LTD., Trentham, Victoria

WHEAT GRAIN

ILLUSTRATION SHOWS HOW

'CERESAN' ACTS

PICKLE WITH

'CERESAN'
BAYER'S DRY SEED DRESSING
(U.T. 1073 &) TRADE MARK

For
BEST GRADE GRAIN
CLEAN GRAIN • MORE GRAIN

WHEAT GRAIN (Greatly Enlarged)
Cut through to show important parts.

'CERESAN' kills all smut spores in 'brush' and 'crease' of grain. This means clean grain at harvest time.

'CERESAN' stimulates germination and gives a better stand of plants, which results in increased yields.

'CERESAN' acts in the soil —Protects young shoots and roots.

'CERESAN' gives a stronger and more extensive root system. Stronger and healthier plants are produced. At harvest time, well-filled grain is the result.

BAYER

DISTRIBUTORS:
DALGETY & COMPANY LTD.
(Incorporated in England)
135B

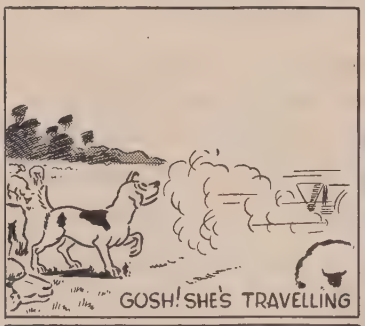
GALVANIZED IRON

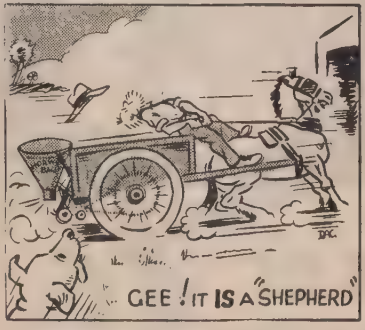
FOR ALL FARM BUILDING PURPOSES

There is no more useful or widely used building material than Galvanized Iron. It is the only practical type of roof for country dwellings, while for fencing, walling, building grain silos, etc., it has no equal. In dry bush areas it is doubly essential, being absolutely fire-proof. Always specify Lysaght's Galvanized Iron.

John Lysaght (Aust.) Pty. Ltd.
SYDNEY — MELBOURNE — BRISBANE — ADELAIDE — FREMANTLE

The only SUPER BROADCASTER that *STANDS THE PACE*





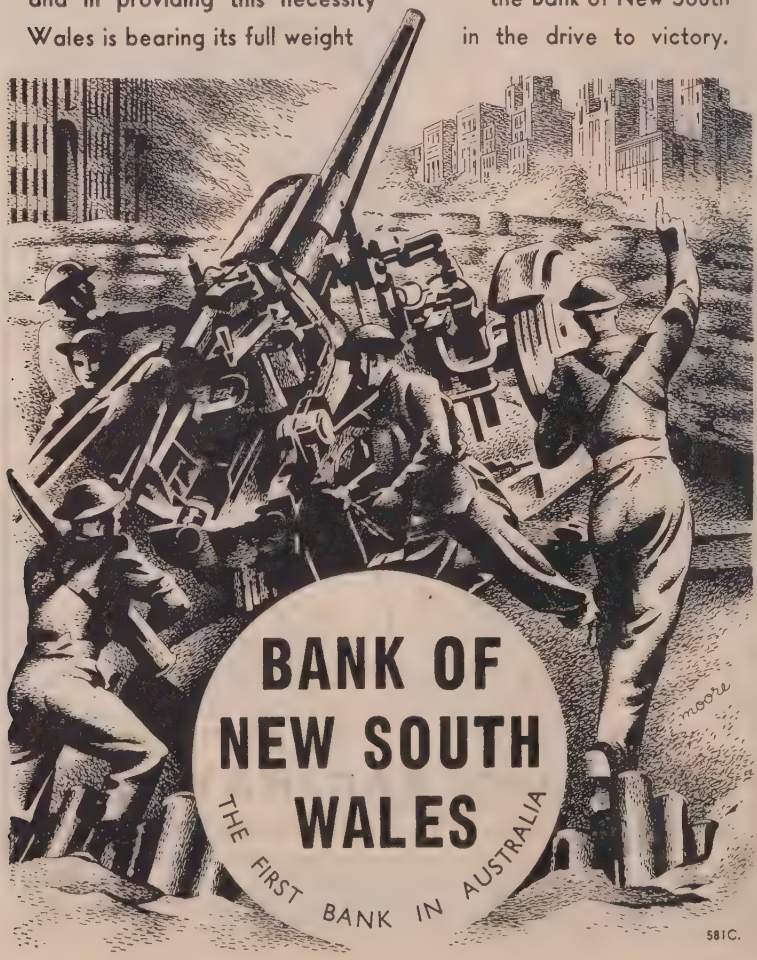
12 Years at work
— Nearly 12,000 sold —
and not a worn-out
"SHEPHERD"
Broadcaster in Australia

Built like a Cream Separator with Oil-Bath Gears and Ball-Bearing Vertical Spindle, Clutch entirely enclosed in Dust-Proof, Oil-Bath Housing. Write for our new 24 page catalogue illustrating Broadcasters for Drays, Waggons, Motor Trucks, Buckboards, also Broadcasters on special steel-wheeled or pneumatic-tyred jinkers.

Agents wanted where not represented.

HORWOOD BAGSHAW LTD.
(Incorporated in South Australia)
78 Currie Street, Adelaide, S.A. 34-38 Young St., Waterloo, N.S.W.

SINEWS OF WAR! . . . Marching men . . . guns and the crews that serve them . . . war factories pouring out a stream of modern weapons and equipment . . . these are the outward and visible signs of Australia's mighty war effort. Less spectacular but none the less real, is another sinew of war . . . bank credit . . . and in providing this necessity the Bank of New South Wales is bearing its full weight in the drive to victory.



581C.

N.S.W. GOVT. OFFICIAL GAS PRODUCER

(Perfected by the N.S.W. Forestry Commission)

Manufactured by

The Producer Gas & Engineering Co.

60 CATHERINE STREET, LEICHHARDT, N.S.W.

COMPLETE UNITS SUPPLIED or, if you build your own unit, we will supply you with the parts: TUYERE, MIXING CHAMBER, DOORS, etc..

4 BIG POINTS *of Superiority of the only Natural Nitrate Nitrogen*

1 *Improves Quality* 2 *Increases Yield*

3 *Promotes Vigour* 4 *Reduces Cost of Liming*

CHILEAN NITRATE OF SODA

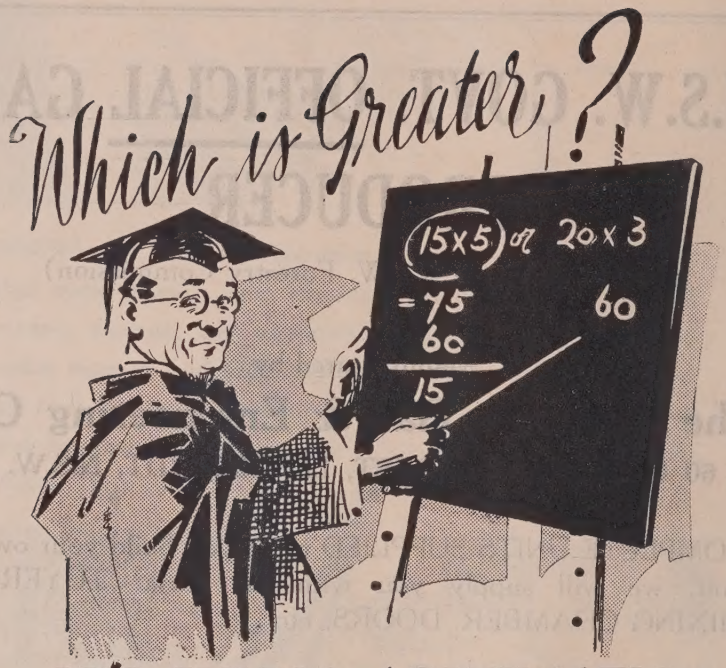
is effective—economical. Contains all the vital elements necessary for healthy plant life. Does not acidify the soil—and its nitrogen is immediately available to the plant.

Growers who use Chilean Nitrate are enthusiastic about its effectiveness and economy.

CLEAN DRY EASY TO HANDLE

Packed in 1 cwt. jute bags paper lined.
Write for literature.

CHILEAN NITRATE OF SODA
AGRICULTURAL SERVICE
44 Margaret St (Box 2037 L G.P.O.) SYDNEY



IT'S SIMPLE ARITHMETIC -

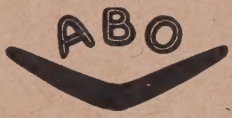
to find that 5 x 15 is greater than 3 x 20. Similarly, you can prove that it costs more to paint your house with "cheap" paint than with BERGER'S PAINT, because it requires more paint and you don't get half the service !

"B.P." has all the qualities necessary for entire satisfaction. "B.P." gives a solid covering that defies the weather, it will protect your property for years and, furthermore, the quality of "B.P." is guaranteed on the can. For satisfaction *on the job,* use —

BP **Berger's Paint** (PREPARED)

THERE IS A BERGER AGENT NEAR YOU

CONTINUOUSLY AT WORK IN SCIENTIFIC AGRICULTURE



FERTILIZERS

W. PATON & CO., MANUFACTURERS
175 Hay Street, SYDNEY, N.S.W.

THE

STATE SAVINGS BANK

OF VICTORIA

THE BEST PLACE FOR YOUR SAVINGS

Depositors' Balances	**£69,218,684**
Depositors	**1,477,133**
Reserve Fund	**£4,045,000**

221 Branches, 387 Agencies

For nearly one hundred years this Bank has been the custodian of the People's Savings in Victoria. Savings facilities are available to suit all sections of the community.

Head Office: 139-153 Elizabeth Street, Melbourne, C.1

SOIL TESTING—
FOR ACIDITY,

pH PEHAMETER, WITH INSTRUCTIONS, 16/- EACH

Laboratory Glassware, Scientific Apparatus, Chemicals.
Milk and Cream Testing Flasks.

H. B. SELBY & CO. PTY. LTD.

393 SWANSTON STREET, MELBOURNE
And at Sydney.

"The Best of all Concentrates"

Over 90% of Stud Breeders feed Meggitt's Linseed Oil Meal in the preparation of their stock for Show, and nearly every cow in Australia which has made an outstanding production record has received "Meggitt's" as an important part of the ration.

These facts prove that "Meggitt's" is regarded as being the best of all concentrates.

Rich in digestible protein of high quality, and with a content of 6% to 7% of laxative medicinal linseed oil, Meggitt's Linseed Oil Meal provides a combination of nutritive and health-giving qualities invaluable in the rations of Dairy Stock, Calves, Pigs, Poultry, etc.

The addition of "Meggitt's" to the ration, not only ensures perfect condition, but also an increase in production which more than amply repays the small cost involved.

MEGGITT'S
LINSEED OIL MEAL

Meggitt Ltd. Head Office: 67 York Street, Sydney.
Address: Box 1555 E, G.P.O., Sydney.
Works: Parramatta, Melbourne, Adelaide.

AUSTRALASIAN MEDICAL PUBLISHING COMPANY LIMITED